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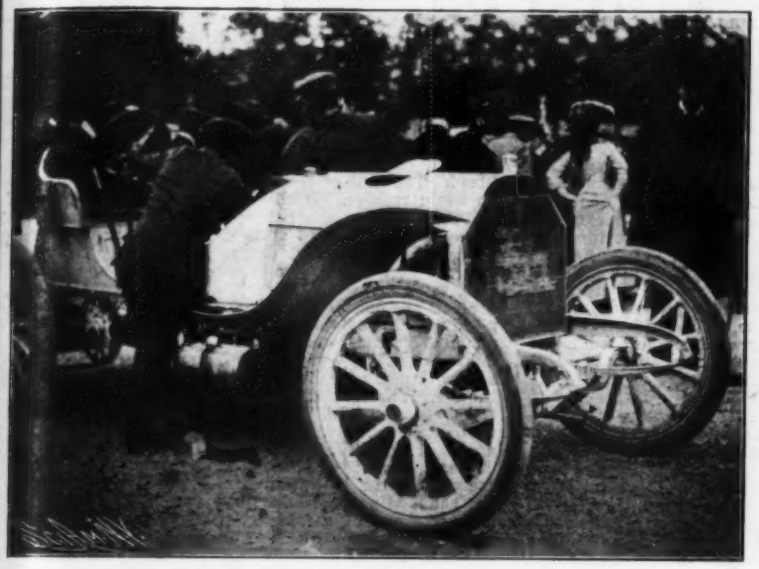
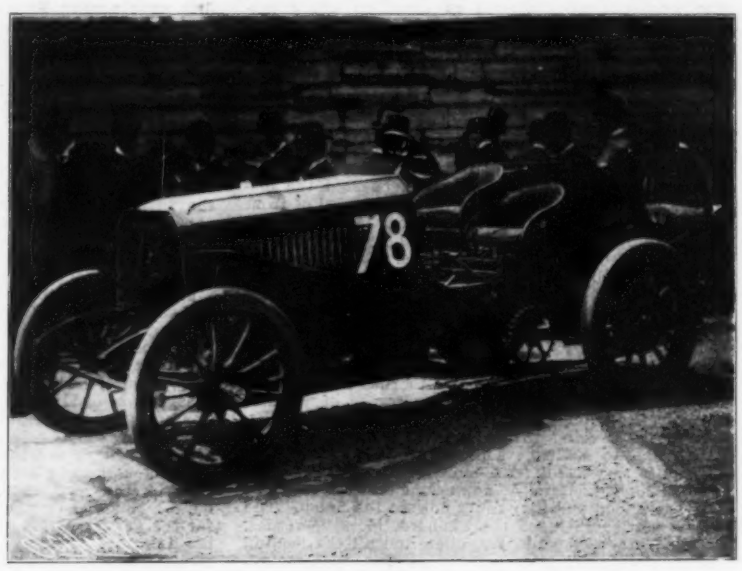
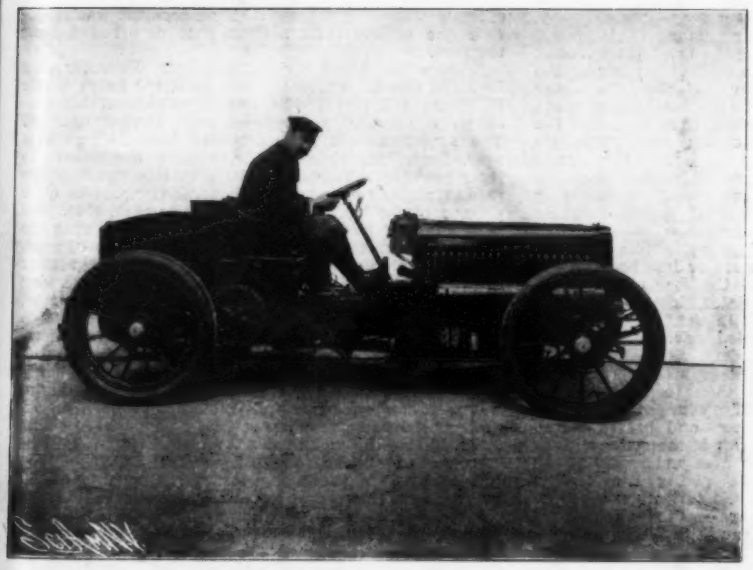


MERCEDES CAR OF WARDEN WHICH TOOK FIFTH PLACE.



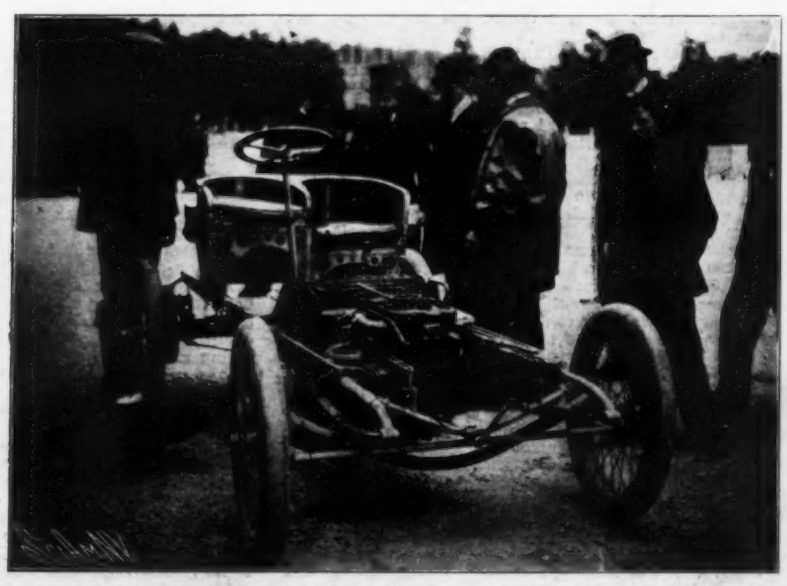
BARON DE CRAWHEZ'S PANHARD, WHICH CAME IN SIXTH.



THE CHARRON, GIRARDOT AND VOIGT CAR WHICH CAME IN SEVENTH.

BARAS ON HIS LIGHT CAR, SECOND IN HIS CLASS.

PANHARD CAR MOUNTED BY BARON RENE DE KNYFF.



GEO. RICHARD VOITURETTE, ONE OF THE WINNERS IN THE VOITURETTE CLASS.

THE RACE FROM PARIS TO MADRID.

THE PARIS-MADRID AUTOMOBILE RACE.

Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT by our PARIS CORRESPONDENT.

THE Paris-Madrid race was to be run in three stages: from Versailles to Bordeaux, or 552 kilometers, on the first day, the 24th of May; from Bordeaux to Vittoria (Spain) on the second day, 212 kilometers; and thence to Madrid on the third day, or 543 kilometers; a total of 1,307 kilometers (784.2 miles). The first stage, to Bordeaux, which was the only one allowed by the authorities, passed through Chartres, Poitiers, and Angoulême. A number of different villages were neutralized, and the chauffeurs were given from 5 to 25 minutes to make the passage. The total time which was allowed for passing through the towns was 3 hours 32 minutes; and this was not counted in the speed contest. The start was placed at Versailles so as to remove it to a considerable distance from the city and give the competitors a free road. The total number of starters, 228 in all, was far greater than ever before. The machines were classed as usual as heavy machines, light machines, voiturettes, and motor-bicycles. All had been carefully weighed at Paris and had a number painted on them indicating the order of the start. Many of the leading chauffeurs had numbers near the first of the series, but this was not always the case, as Gabriel, the winner of the race, had the number 168. There were some gaps between the numbers, as certain of the cars dropped out for various reasons, after receiving their numbers.

The winners, as will be observed, covered the distance to Bordeaux, 331.2 miles, in times varying from 5 hours, 13 minutes, 31 seconds, to over 14 hours. The latter were in most cases detained by accident, as most of the cars made high speeds. Gabriel on his Mors racer, and some of the others, must have reached 70 or 80 miles an hour. It will be noticed that the moto-cycles have been entirely replaced by the motor-bicycles; these make very fast time, and reach the speed of an express train.

A touring race had also been organized in connection with the speed race. The tourists started from Paris on the 13th of May, crossing France in a southwesterly direction to Bayonne, then crossing the Pyrenees and passing through Burgos, Valladolid, and Salamanca, to Madrid. This part of the programme was quite successful, and most of the tourists had reached Madrid before the news came that the race had been suspended and they could not see the finish. The tourist section included the Panhard, Mors, Mercedes, De Dion, Ader, Renault, Serpollet, and all the leading makes carrying from two to six persons, with motors ranging from 7 to 40 horse power. These long runs have been so successful that they are beginning to be regarded as a common occurrence, while only a few years ago this performance would have been considered remarkable. Besides, the chief interest centered in the speed race, and the appearance of the new cars was awaited with curiosity, as their construction had generally been kept a strict secret before the race, each of the makers fearing to give points to his competitors.

Attention has of course been attracted by the winning machines, and therefore a short description of each will be of interest. The engravings show the general appearance of some of the more important cars. The Mors machines naturally take the first rank, as one of them won the race to Bordeaux and another took third place in the general list and second among the heavy cars, while another Mors, mounted by Achille Fournier, holds eighth place in the general list. All these machines are similar in appearance. They are of handsome design, and their general lines indicate that they are built for high speed. The torpedo, or boat shape, has been adopted, with a sharp point in front, while the rear also ends in a point. The radiator is almost concealed from view under the front part. The motor is built to give 80 or 90 horse power, and is one of the most powerful gasoline motors yet constructed for a racing machine. Magneto ignition is the type employed. The motor is well placed and solidly mounted in the front of the chassis. Instead of resting on the side bars of the frame by means of arms which are cast with the aluminium crankcase, the motor is lodged in a bed-plate of pressed steel which is proof against shocks. The suspension of the body is well carried out. To the usual springs is added a kind of braking device which deadens the oscillations of the springs after the car has passed an obstacle. This ingenious device was brought out not long ago by Truffault.

Next to the Mors, the Panhard & Levassor cars were the general favorites, although they did not succeed in taking higher than sixth place with Baron De Crawhez, owing to accidents which happened to the different cars. One of the Panhard racers was piloted by Réné de Knyff, who is well known for his different records, a third and fourth by Henri and Maurice Farman, and others by Chauchard, Teste, etc. The Panhard racer is equipped with a 70 horse power motor, and is thus not quite as powerful as its nearest competitors, the Mors and Mercedes. The exterior of the vehicle does not differ greatly from the preceding models. It has a square box front which is finished off by the radiator. One particular feature of the new racing car is the unusual position of the motor. The constructor wished to lower the center of gravity of the car by lowering the motor. At the same time he wished to give the latter a heavy flywheel of large diameter, but without bringing it too near the ground. He solved the problem by inclining the motor toward the front so that the lowest point of the crankcase and the lower edge of the flywheel are on the same level. The diameter and stroke of the motor are kept the same as last year's type which was used in the Paris-Vienna race. The motor has four large cylinders with water jackets formed by an outside copper sheathing. The only difference in the operation of the new motor is that the admission valves are now operated mechanically. The new Krebs' carbureter is now employed which allows of keeping a constant mixture of gas and air at all speeds of the motor. The flywheel has been made heavier, owing to its increase in diameter. The chassis is built of pressed steel, and is very solid as well as light. In the center of the car are the seats for the driver and machinist which are placed rather high up. The racing machine has only three speeds, as it was desired to save weight by diminishing the number of gears in the transmitting mechanism rather than by lightening the chassis too much and depriving it of the necessary rigidity. Chain transmission is used from the countershaft to the rear wheels. The radiator, which forms the front end of the car, has been built in a compact form, and air is forced through it by a fan which is placed in front of the motor and is driven from it by a belt. The escaping gases come out of each of the four cylinders by a short pipe, and all four pipes are joined below to a long tube of large diameter like a stovepipe, which conducts the gases to the rear and serves as a muffling box. The suspension of the car body has been well carried out, and the *ensemble* forms an easy running machine of great solidity.

The new Mercedes racers attracted a great deal of attention. They are of German build and come from the Daimler works at Canstatt. This firm holds the first rank among German constructors, and it has a well-deserved reputation for automobiles of high quality, but this is the first year in which the Canstatt works have turned out a series of regular racing machines. During the Paris-Vienna race, some of the Mercedes cars came very near taking the first place, although they were only equipped with light motors. For the Paris-Madrid race two new types were built, one of 60 horse power and the other of 90 horse power. One of the 60 horse power machines ran not long ago at Nice, but this is the first appearance of the 90 horse power car, which was one of the most powerful machines in the race and was only exceeded by the Gobron-Brillié, which was built to be run with alcohol and rated at 110 horse power. The latter did not, however, succeed in taking a high place in the race. The Mercedes machines are built according to the standard type as to general appearance, and all the machines are about alike, differing only in the power of the motor. The type of motor used has 4 cylinders, and is of especially compact form. The long, square, bonnet is finished off by a radiator of the honeycombed pattern, which has a fan behind it. Contact ignition, with current from a magneto, is used. The speed-changing box has sets of gears which are always in mesh and the clutches of which are thrown in by a rack-and-pinion device, which is operated in turn by the speed-changing lever at the conductor's hand. Mounted on the steering wheel are the levers for the gas admission to the motor and for regulating the ignition. The motor is thrown into gear by a new form of clutch in which a steel spiral winds around a cone and can be made to turn the latter by attaching the free end to the cone by means of a catch device, the whole working somewhat on the principle of the capstan.

The new De Dietrich cars are among the winners, they having succeeded in taking the third place among the heavy machines, under the skillful driving of the Englishman, Jarrott. This car had also the honor of leading off at the start. The performance of these cars is all the more creditable from the fact that the system was only brought out last year. The De Dietrich Company decided to abandon their former system, and adopt the new type which had been designed by Turcat and Méry, two young engineers of Marseilles, and which showed great promise. Their expectations have therefore not been disappointed. The cars were built in slightly varying forms on the present occasion, but all are more or less boat-shaped, with a long pointed front and the rear either tapering or rounded off. The radiator, instead of being placed underneath the body as in the Mors, is placed directly in front of the pointed end. A 4-cylinder motor is used, with the cylinders grouped in pairs. The efficiency of the new system is due rather to the perfection of the details than to anything unusual in the construction. The chassis is built of wood, reinforced by pressed steel and braced across by steel tubes. The motor and the transmitting mechanism are supported upon a second frame at the front and inside the chassis, giving considerable rigidity to the whole. The wheels turn upon specially designed ball-bearings, and have an easy movement. The motor, which is built to run with either gasoline or alcohol, used gasoline in this race. The cylinders are cast in one piece with the water-jackets. The new De Dietrich machines made their first appearance at the Paris-Vienna race last year, in which three 16 horse power racers showed up very favorably in comparison with the heavier machines. The radiator for the water cooling is provided with a turbine pump of large output, but in case of accident to the pump, the cooling can still be carried out on the thermo-siphon principle, owing to the disposition of the water reservoir. A magneto is used for the ignition, with an induction coil in reserve. An improved carbureter is employed, which assures a constant mixture at all speeds of the motor. It works at constant level, with an atomizer which uses a double air current. A friction-clutch couples the motor to the speed-changing box which gives four different speeds. In these cars the motor has been increased to 45 horse power on an average, or 60 maximum.

The Renault car was also one of the winners and upheld its reputation of last year. The new racers embody all the new points which have been illustrated in detail in the SCIENTIFIC AMERICAN. This year the racing machines of the Renault type, and in fact most of the others, were finished only a few days before the event, and were not to be seen before that time. After the race most of the machines were detained at Bordeaux, and have not returned to Paris at the time of the present writing, but it is expected to soon furnish a detailed description of these, as well as of the other leading machines.

The race was especially marked by the accidents which occurred to many of the leading chauffeurs and to many of those who were counted upon to win the race. The death of Marcel Renault, the winner of the Paris-Vienna race, who was precipitated from his machine against a tree and had his skull fractured, is deeply regretted. It is a curious fact that last year it was Louis Renault who met with an accident and could not finish, while his brother won the race, while this year the conditions have been reversed. The Renault brothers went into the construction of automobiles in a rather unusual way. They were great amateur yachtsmen, and had a small steam yacht, the "Cypris," which they ran on the Seine near Paris. Having a small tool-shop for repairs, they had an idea of constructing a quadricycle in 1897 with a speed-changing transmission of their invention. Then they built a voiturette, to which they applied the same speed-changing device and brought out for the first time the jointed rod transmission which is now used so extensively. This voiturette was built for private use, but had such a success that they constructed others, and finally founded, in 1898, their present works just outside of Paris. The new machines soon became successful in the different races and, in 1899, Marcel Renault took second place with his voiturette in the Paris-Trouville and the Paris-Ostend races. The following year Louis Renault took the first place among the voiturettes in the race from Paris to Toulouse and back. After running in the Paris-Berlin, Marcel Renault became famous as the winner of the Paris-Vienna race of last year, showing that his light machine was to be counted upon as a competitor against the heavy cars, and this has also been proved in this year's race by the second place which was won by Louis Renault. As a chauffeur, Marcel Renault was remarked for his *sang froid*, and for his skill as well as prudence in driving.

Two of the chauffeurs who met with serious accidents during the race were Lorraine Barrow and Stead. The case of the former is serious, but he will no doubt recover. Stead expects to be able to return to Paris within a short time, as his accident is not as grave as was reported at first.

One of the principal causes for stopping the race was the fact that a soldier was killed by one of the cars, some say while on duty, but this has since been denied. The official account of the accident, which took place near Angoulême, is as follows: The Tourand car, mounted by M. Tourand, arrived at the bridge of Le Couronne at a speed of over 70 miles an hour. The bridge formed a slight arch and made the car bound in the air. The machinist Normand, who had just then risen up to examine the route and was leaning over the car, lost his balance. Seeing himself about to be projected from the vehicle, he caught the arm of M. Tourand, giving the latter a brusque movement which caused the car to swing to the right and run into the bank. Upon the bank were placed several spectators, and one of these was the soldier Dupey, who, while trying to pull a child back out of the way, was struck by the car in the chest and instantly killed. The car, continuing on its course, ran into a tree and smashed to pieces, throwing the conductor and machinist out on the road, killing a spectator and severely wounding a second. This accident was therefore one of the most serious that occurred during the race.

Besides the more serious accidents, Fournier and De Knyff met with mishaps and could not finish, while M. Georges Richard, who was thrown from his machine, will probably escape without serious damage. The Americans did not meet with good fortune this year. Both Vanderbilt and Mr. Terry had accidents to their machines. Vanderbilt states that he gave up the race principally owing to a punctured tire, but he complained of the bad organization of the race, also. He had considerable difficulty at the start owing to various formalities. He says that the crowds of spectators all along the route were one of the greatest drawbacks to the chauffeurs, as imprudent persons advanced far into the roads in order to see the cars, and there was no one to control them, at least outside of the towns and villages. It was not surprising therefore that there were a great many accidents to the spectators, and upon learning this he was not sorry that he had given up the race. Baron de Forest, who was also stopped owing to a puncture of his tire, expressed the same opinion.

Mr. Terry, the well-known American chauffeur, had a very bad accident to his machine which obliged him to give up the race. Mr. Terry mounted a 60 horse power Mercedes car, and 12 miles after the start, when he was going at a very high speed, at least 60 miles an hour, came alongside of one of his competitors just before the town of Cognières. On passing Cognières over a bad piece of road, Mr. Terry, who is a skillful driver, tried to pass the second car on the left hand side, but just then the latter made a turn to the left also, and in order to avoid a collision, Mr. Terry was obliged to turn his machine on to the sidewalk. This gave a rude shock and caused the tire of the left wheel to burst, but the car, running at a high speed, still drove ahead and passed the second machine. Then the left wheel broke, and although the motor was thrown out of gear, the car kept on for about a thousand feet, traveling sidewise along the road at a speed of 50 miles an hour. The shock had caused the gasoline reservoir to burst, and it contained 30 gallons of gasoline, which saturated the machine. The gasoline caught fire from the exhaust of the motor, and when the car finally came to rest, it was enveloped in flames. All this time Mr. Terry, with rare *sang froid*, continued in the seat, but was forced to leave the burning vehicle. No accident occurred to either Mr. Terry or his machinist, but it is reported that the car was completely burned, together with two trees at the side of the road.

The wind-up of the event was as doleful as the beginning had been brilliant. The cars, on reaching Bordeaux, were kept under lock and key by the authorities, and as they were not allowed to leave under their own power, they had to be towed to the railway station by horses and thus sent back to Paris. Following the decision of the French government, the Spanish government also issued a decree forbidding the race in their territory. The different fêtes which had been organized to receive the chauffeurs had to be all countermanded. Considerable excitement was caused at Paris by the news of the accident, and many of the journals who are hostile to the automobile raised a great cry. Others took a calmer view of the matter, but nearly all agreed that the day of fast racing on the road was over, in France, as the speeds had now become so high that accidents were sure to

occur. Those who are favorable to automobile interests are looking for some way to solve the problem, as it must be admitted that the present perfection of the automobile in France is principally due to the high-speed races, and the perfection of the light gasoline motor is now the cause of the success which the new airships are having.

The affair was discussed in the Chamber of Deputies, and the general opinion may be summed up by the statement of M. Combes, the President of the Chamber. In authorizing the race he was far from expecting such terrific speeds, and he considers also that the number of accidents to the spectators has been exaggerated. The greater part of these were due to defects in the route or the imprudence of the chauffeurs, and not to the lack of precautions. It is only the excess of speed that is dangerous. The government is not disposed to allow a new attempt to be made, but it warns the Parliament against an exaggeration of sentiment which would lead it to vote too severe measures and thus ruin the automobile industry which is now so prosperous. Both the industry and safety to human life should be looked after, and these two interests should be conciliated. This can no doubt be done if the affair is looked at in the right spirit. The Marquis De Dion, the well-known automobile constructor, who is also a deputy, replied that he was satisfied with the attitude of the President, adding only that the number of accidents per mile caused by horses is much greater than for automobiles, and that no new restrictions should be made which should compromise such a flourishing industry and one which supports so many workmen. As a result of the debate no further measures have as yet been taken against the automobile interests in general, except that of prohibiting the speed races which will now have to be held on private roads, and there is already some talk of acquiring property and laying out an immense circular road, or "autodrome," to be devoted to the automobile.

It was of course of great interest to know what effect the decision in France would have upon the Gordon Bennett Cup race which is shortly to be held in Ireland. The executive committee of the British Automobile Club held a long session, and, as a result of the debate, made the statement to the public to the effect that the International Race should not be placed in the same class as the Paris-Madrid for many reasons. The great source of danger in the Paris-Madrid race was the character of the road surface. A constant cloud of dust hid the sharp corners and prevented the drivers from seeing the gullies, which are occasionally cut across the road. In Ireland, however, arrangements have been made to spend nearly £1,500 in removing the gullies and sharp bridges, and all corners will be treated to prevent dust being raised. The whole road will be put into proper condition for high-speed racing automobiles. On the road between Paris and Madrid there were several dangerous railway grade crossings; there are no grade crossings on the Irish course. It may be further stated that the drivers of automobiles in the *Coupe Internationale* are already carefully studying the Irish route. They will, before the beginning of July, know it in all its detail, and will be thoroughly familiar with the speed at which the various corners can be safely negotiated. Almost every cause which contributed to the accidents in the first stage of the Paris-Madrid race will be absent from the *Coupe Internationale* race, and there is little fear that the mishaps which startled and alarmed the public in connection with the former race will repeat themselves in Ireland.

THE BRITISH FIRE PREVENTION COMMITTEE AND ITS WORK.

By the ENGLISH CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

THE term "fire prevention" is too often misunderstood, inasmuch as fire extinguishing, or rather fire-brigade work, is what the majority has in its mind, and many towns consider themselves well protected if they can boast of an efficiently manned fire-engine establishment.

In reality, however, fire-brigade work, as such, occupies but a minor rôle in the general system of fire protection, for really well protected towns must owe their position in the first place to properly applied preventive legislation, and a preventive practice based on the experience and research of architects and engineers, fire experts, fire-brigade officers, insurance and municipal officials.

Fire protection is a combination of fire prevention, fire combating, and fire research, and under the heading fire prevention should be classed all preventive measures, including the education of the public.

Preventive measures may be the result of private initiative, but as a rule they are defined by local authorities, and contained partly in building acts and partly in separate codes supplemented if necessary by rules for the treatment of extraordinary risks, such as the storage of petroleum, the manufacture of explosives, or the performance of stage plays.

The work of the British Fire Prevention Committee relates in the first place to fire prevention pure and simple, and in the second place to fire research, while its sphere is not intended to encroach upon what is generally termed fire combating or fire extinguishing, although mutual interests naturally bring the committee in touch with those who have the combating element in hand, i. e., the professional, part-paid, and volunteer fire services, as well as the salvage corps.

As fire-brigade officers in different countries are handed together to discuss subjects relating to fire combating, and to exchange experiences, so in England architects, engineers, district surveyors, municipal officers, and the members of the other technical professions interested have joined hands to deal with that part of the general subject of fire protection—namely, fire prevention—in which they are mainly interested. And just as the associations of fire brigades include frequently members of the technical professions who are interested in fire-brigade work, either from an engineering, chemical, or other point of view, so there are fire-brigade officers who have joined the British Fire Prevention Committee whose work so materially affects them, and has, in fact, a very important rôle to play in the safety of a fireman's life.

The British Fire Prevention Committee was formed after the Paris Charity Bazaar fire and the great Cripplegate fire in London, in both of which cases it was obvious to the world that the subject of fire prevention was really in its infancy.

The committee was formed first as an ordinary private society, and afterward as an incorporated committee with a membership of over five hundred professional men, and the necessary funds for its maintenance are raised by a regular annual subscription among the members and by voluntary contributions. The principal objects of the committee are as follows:

To direct attention to the urgent need for increased protection of life and property from fire by the adoption of preventive measures.

To minimize the possibilities and dangers of fire.

To bring together those scientifically interested in the subject of fire prevention.

To discuss practical questions on fire protection.

To undertake independent investigations and tests of materials, methods, and appliances.

The tests which have been instituted by the British Fire Prevention Committee have been limited to obtaining reliable data on the exact fire resistance of various materials and systems of construction, or appliances used in actual building practice in Great Britain; in other words, they have been limited, so far, to obtaining results bearing on the every-day practice of the building world, rather than to dealing with theoretical work.

The reason for these investigations is that sufficient data does not exist as to methods of building construction, and that the little information available has, to a very considerable extent, been obtained by individual makers or manufacturers in their own laboratories, and that the results thus obtained have not been met with much confidence.

The few official tests that have so far been undertaken in this country and in Germany have not hitherto been systematically organized, but have simply had the object, as a rule, of dealing with certain specific questions or a certain specific piece of material employed in a particular building, rather than of treating the question of fire prevention as a whole.

The series of tests undertaken by this organization thus not only fill a long felt want, but give the fire-prevention trades an opportunity of obtaining authentic records as to the reliability of their work.

The tests are of an entirely independent character, arranged on scientific lines, but with full consideration for the practical purpose in view. Absolute impartiality is assured, records being mostly taken automatically and by photography, while the temperatures are carefully regulated and maintained, as the means for applying heat is by the combustion of gas.

All reports on tests state solely the bare facts and occurrences with tables and diagrams and illustrations and do not in any way intimate expressions of opinion, comparison, or criticism.

The general arrangement and direction of the tests is in the hands of the executive, and in accordance with certain principles laid down after careful study and experiment.

The actual tests are attended by the members of the council and the members of the committee in rotation, care being taken that the attendance is always thoroughly representative of the technical professions primarily interested in the specific object under investigation.

The first testing station is at Westbourne Park, London, W. For this purpose an old and commodious residence with its grounds was purchased. The principal rooms are used for committee and reception room, a museum, laboratory, and photographic dark room and a residence for the resident engineer. A portion of the garden is occupied by the huts in which tests are conducted.

With regard to the financial aspect of the station, the establishment expenses are met by a special subscription, and, as far as the funds of the committee permit, investigations with ordinary, i. e., not patented, forms of construction are undertaken from time to time and duly reported upon. Official tests with patented materials, makers' systems, etc., are subject to a scale of charges so regulated as to only just cover the actual cost. The testing station is also open to members for such private research work or tests as they may desire to undertake at nominal charges for the loan of plant and instruments.

The services of the members participating in the management of the station conducting or attending tests are given entirely gratuitously.

The testing plant comprises a set of testing huts in which floors, partitions, doors, or ceilings can be tested. The huts are laid down in two rows, and the materials used in their construction are stock bricks with lime mortar.

The fuel used is gas, produced on the spot. The gas is conveyed from the generator by pipes to the several huts and the supply is regulated by valves and dampers, and as the gas enters the huts from the branch pipes it is diffused by means of mixing chambers of fire-brick. Each hut has door openings, ventilation and observation holes, the doors being closed by brickwork during a test, and the ventilation holes blocked according to requirements by fire-brick or fire-clay.

Each chamber for a floor test allows for the floor under investigation to be placed at least 7 feet 6 inches above the floor of the hut, and the chambers are roofed in with galvanized iron or tarpaulin when necessary. Bricks or pig-iron are used for any loads that may be applied to floors under investigation, and water is applied from an ordinary manual pump equipped with pressure gage.

While the tests are in progress records of temperatures are taken as far as possible automatically, by electrical pyrometers able to record temperatures up to 2,500 degrees F. Visual observations of work under investigation are also recorded as far as possible by photography. Deflections are measured by level and staff or by weights and pulleys.

The general arrangement and direction of the tests are in the hands of the executive, the work being done according to certain principles laid down by them after careful study and experiment. The actual tests are attended by the members of the council and the members of the committee in rotation. Attendances at tests have to be strictly limited in accordance with the regulations of the testing station, for, quite irrespective of the fact that any crowding disturbs those directing the operations and that the actual attendance is by no means free of danger, there is the question of vibration; for instance, the movements of people in the house are distinctly felt on such delicate instruments as pyrometers.

For the regulation of the attendance of tests, with due consideration for the representation of the committee, and also of the exhibitor (should it be the case of a patented piece of construction, system, or appliance), the following arrangements are made:

The official attendance at tests with materials, systems, or appliances of members of the commercial section is limited to the council and executive, ten members of the committee, the chairman of the commercial section, six representatives of the exhibition, two visitors nominated by the exhibitor, and such special visitors as the executive may have invited.

(1) Members or visitors attending a test must not in any way directly or indirectly publish or allow to be published any description, account, or criticism of the test. Exhibitors or their representatives are also expressly forbidden directly or indirectly to publish or allow to be published any description, report, account, or criticism of the test, other than the duly authenticated official report of the committee, without abbreviation.

(2) Members, exhibitors, or visitors must not hold the committee, its council, executive, or officers responsible for any personal or other injury, loss, or damage, sustained at a test or while visiting the testing station, whether through accident, negligence, or otherwise.

(3) Members, exhibitors, and visitors undertake to conform implicitly with the rules in force at the testing station and to comply with all instructions given by the executive and its representatives.

Every test is in charge of a special sub-committee of the executive, of whom one is the directing member. The complete technical direction is in their hands and each member of the sub-committee wears a distinguishing badge. A member of the executive is delegated at each test for the reception of members and visitors.

The members of the sub-committee in charge of any one test and the officers and the employes of the committee, must not be interfered with during the test by visitors and others wishing for explanation or information. The executive has powers to determine the distance within which members and visitors may not approach the testing huts, instruments, or appliances during the progress of any test. Nor may any hut be entered or examined without special permission of the directing member of the sub-committee in charge of the test, and any such permission does not involve any responsibility on the part of the directing member or that of the executive, council, committee, or its officers.

Tests of fire resistance of the ordinary building materials, or forms of construction which are not subject to any patent, or the interest of any special maker, are undertaken from time to time by the committee according to the means at the disposal of the executive for such purposes. It rests with the executive, either of its own initiative or at the instigation of others, to arrange for tests of this description, and it is hoped that the various public authorities interested in the subject will in due course contribute financially toward the cost of such experiments as they may consider of general public utility.

Up to the present the executive has tested several floors of various construction, as well as wood and iron doors.

It is needless to say that there are endless questions relating to the fire resistance of ordinary forms of construction that have yet to be solved, and it is hoped that further research will be made in this direction as means permit. It is anticipated in due course to record the exact resistance of all the more common methods of construction used in the British Isles.

As already indicated, quite irrespective of the test undertaken by the committee with work not subject to patents, or not the specialty of individual makers, the fireproofing trade also has every opportunity for obtaining official and independent reports on its systems or appliances, at a fixed tariff. The charges are based on the actual costs of such tests. In the event of any of these testing charges leaving any material surplus, such surplus is, after due consideration of wear and tear of plant, instruments, etc., distributed among the firms or individuals who have had work tested proportionately to the amount of the testing charges originally paid by them, or the surplus is utilized for such other purposes as the commercial section directs. This section is representative of the fireproofing trade of Great Britain, and organized under the auspices of the committee, some seventy-five firms and others interested in the trade aspect of fire prevention participating in the operations.

The tariff reads as follows:

For purpose of finance, the cost of the test is divided into (1) preliminary expenses, (2) establishment capital, (3) testing charges.

All firms or individuals not members of a firm desiring tests contribute a donation of $26 to the preliminary expenses incurred by the British Fire Prevention Committee in forming the station.

All firms or individuals desiring tests contribute to the establishment capital of the station from $50 to $250, according to the nature of the test and the group to which it belongs, as defined below.

All firms desiring tests pay in form of testing charges from $125 to $500, according to the nature of the test and the group to which it belongs.

These contributions and charges cover all expenses for ground, frame, walls, ovens, or heating apparatus, instruments, firing, loading, water, attendance, and supervision. No responsibility for breakage of instruments, etc., is incurred.

The firm or individual having work tested supplies and fixes his materials, systems or appliances at his

own cost, everything pertaining to the actual test being covered by his contributions per scale.

When second tests are desired by the same firm or individual, the testing charge, no matter in what group, is according to scale, but there is an exemption from further contribution to the establishment capital, or preliminary expenses. Where three or more tests are undertaken for the same firm or individual, a discount of 10 per cent off the scale charges is additionally allowed.

Under exceptional circumstances, at the discretion of the executive, and under special conditions to be determined on, tests may be undertaken elsewhere than on the committee's grounds.

Quite irrespective of the independent tests, the testing grounds are, under special conditions, available to members of the section for private experiments, private investigations, etc., and research work of a private character. Every encouragement and facility is afforded to members undertaking research or experimental work. Such tests have, however, to be conducted purely as private tests and no report on investigation of this description may be issued by the maker, as it is of the utmost importance that the only reports issued in respect to work carried on at the testing station should relate to the official tests conducted under the auspices of the committee.

In framing the reports issued by the committee, it is well to again emphasize the fact that every possible precaution is taken in wording them to avoid any semblance of opinion or comparison. They are drafted solely as a bare record of facts, and are intended to be read as such.

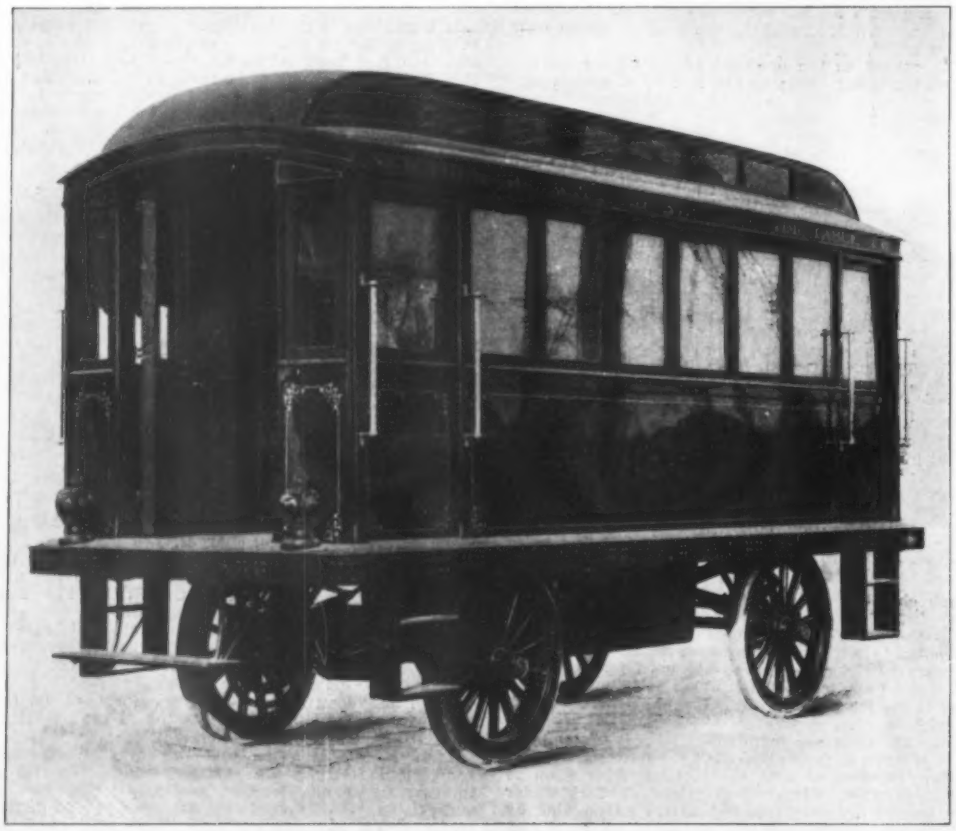
In the case of makers' tests, the exhibitor has an opportunity given him to put any grievance before the executive prior to the issue of the report dealing with his individual test, and any observations on his part receive the full consideration of the executive.

The reports are published at the direction of the executive and they are not only distributed among the members of the committee but among such nonmembers as is thought advisable, including the officials of the leading public offices.

AN AUTOMOBILE PULLMAN CAR FOR TIME-TABLE DISTRIBUTION.

ONE of the many curious sights to be seen on Broadway is an electric automobile with a Pullman body, which is used for the distribution of time tables. This wagon serves all of the railroad offices, depots, and hotels in Manhattan and Brooklyn. Some of the routes are twenty miles long; and while horses were formerly used to do the same work, the automobile is found to be more economical. The four steps, the large brass handles, the headlight and the tail-lights were put on to heighten its resemblance to a railroad car. At the rear of the curtains of the windows are pigeon-holes or boxes, 164 in all. When filled these will hold about 2½ tons of folders, and additional bundles can be carried upon the floor. The boxes are arranged so that the location of any individual time table will be the same as the racks in the hotels or stations. Motive power is supplied by two General Electric motors geared direct from the motor pinion to the driving gear. Each motor operates a rear wheel, the axle being fixed. The source of power is forty-four storage batteries of the "Exide" type, thirteen plates to each cell. There are four speeds ahead and two speeds backward. The vehicle has a radius of 30 miles on one charge of the battery, and the maximum speed is 9 miles per hour. The car is lighted by electricity, and there are also lamps in the head and tail-lights.

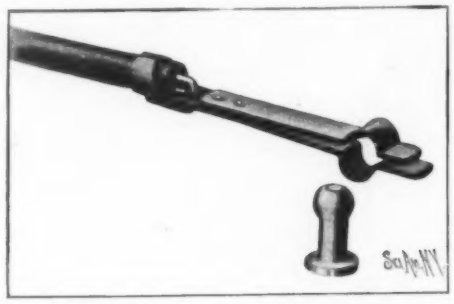
Previous to the establishment of this business of delivering folders of all roads, sixteen years ago, each railroad and steamship line employed a man to carry around and distribute the folders. This resulted in a great waste; and as there was no system for exchanging them when changes were made in the running time of the trains, the public could not have absolute faith in the correctness of the folders. Now, however, the time tables of each road are kept in a special partition of the racks in public places, and exchanges are made within twenty-four hours after the time of the trains is changed. That the public appreciates this system is demonstrated by the fact that over 5,000,000 folders per year are distributed in the metropolitan district. The new car is also an accommodation to the traveling public, as they can obtain time tables from one of the attendants without having to go to a railroad or steamship office.



AN AUTOMOBILE CAR FOR DELIVERING TIME TABLES.

DEVICES SUGGESTED BY THE JARRING OF AUTOMOBILES.*

THE task of building a machine of inconspicuous dimensions, which may be conveniently placed in a vehicle for propelling the same at a high rate of speed, is in itself a great one, without making allowances for the jarring and racking effect of driving the machine over rough country roads or city pavements.

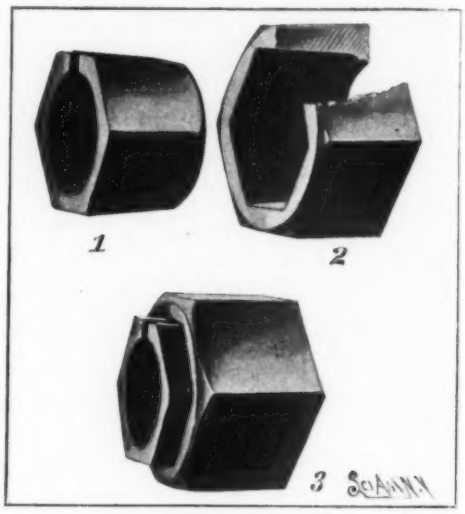


TRACY SPARK PLUG CONNECTOR.

The smallest details of the mechanism have to be attended to with the greatest of care, lest some important part work loose and bring about disastrous results. This has afforded an excellent field for invention in recent years. We have illustrated a few of the devices introduced, which will give an idea of the great variety of inventions suggested by this one feature.

A frequent source of trouble on gasoline-driven automobiles occurs at the connection of the wire from the spark coil to the spark plug. Ordinarily, the secondary wire is fastened to the spark plug by binding screws. These, however, are liable to work loose sufficiently to permit the wire to slip off the plug. Even with this defect overcome, and a rigid connection made, the wire is liable to break owing to the constant jarring and swinging. Our illustration shows a metal clip which insures a perfect connection to the spark plug under all conditions. The clip comprises two spring arms adapted to be slipped over the terminal post of the sparker. The clip is secured, not to the wire itself, but to the heavy insulation, by projections which are bent over thereon. Electrical connection between the wire and clip is made by passing the wire through openings in the clip and bending it back upon itself as shown. A small brass ball is screwed on the stem of the spark plug. The clip slips over this ball and clamps it tightly, thus making the necessary connection to the plug. By fastening the clip to the resilient insulation of the wire, danger of a break in the same is entirely avoided.

A more common source of trouble is the jarring loose of nuts. The importance of a perfectly reliable lock-nut is especially appreciated by automobilists. Many inventions have been brought forth to overcome this tendency. One of these which has met with great success comprises two parts, as shown in our engraving. The threaded part, or nut proper, Fig. 1, has a tapering hexagonal exterior. This is adapted to fit into a correspondingly-tapered hexagonal bore in the other section, as shown in Fig. 3. In screwing the nut on the bolt, the wrench is applied to the exterior member. This causes the threaded members to turn and feed on to the bolt. When the exterior member has been seated, further turning with the wrench results in drawing the threaded member tightly into the bore of the exterior member. The threaded member, it will be observed, is a split-nut, so that it will be compressed on being drawn into this tapered bore, thus gripping the bolt more tightly.



COLUMBIA LOCK NUT.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

DENSITY OF GASOLINE REQUIRED TO OBTAIN GREATEST HORSE POWER AND MOST EFFICIENT WORKING OF GASOLINE MOTORS.

A SERIES of experiments have been carried out in England with a view to determining the specific gravity of gasoline for the most efficient working of gasoline automobile motors. Some manufacturers have experienced considerable difficulty in developing the anticipated and theoretical horse power from their motors on the test stands, a fact ultimately assigned to the varied density of the gasoline. Some engines have proved to be more efficient in their working with a spirit of 0.685 specific gravity, while, on the other hand, it is contended by distillers that a density of 0.720 is in every way as suitable for use in internal combustion engines as generally used on automobiles. Until the advent of the motor car, gasoline was practically a waste product of the petroleum refineries, with the result that a large stock of spirit varying from 0.680 to 0.685 density accumulated. When the gasoline motor was introduced, however, it was designed to work with a spirit of this specific gravity, and now the density has been increased, the engines fail to produce such good results as were previously obtainable. The Daimler Motor Car Company, of England, have carried out a series of tests with spirits of 0.690 and 0.725 densities, to obtain conclusive data as to whether the attributed loss of power was due to the heavier spirit.

Five brake tests were made as follows:

Specific gravity of spirit.	Engine speed.	Load in pounds.	Fuel in pints.	Time of run.
0.725	980 revs.	85	4	23 mins.
0.725	1,000 revs.	84	2	11.1 mins.
0.690	1,000 revs.	88	4	22 11/16 mins.
0.690	1,000 revs.	94	2	11.28½ mins.
0.690	1,000 revs.	89	2	11 mins.

From the foregoing it will be recognized that there was an approximate advantage of 5 per cent increase in the development of power by the utilization of motor spirit of 0.690 density than with that of 0.725 specific gravity. There was also another disadvantage accruing from the use of the heavier spirit. Combustion is not so perfect, which fact tends to produce a sooty deposit in the combustion chamber, and which in a short space of time fouls the sparking plug and causes misfiring. In fact, a great majority of the troubles arising from the employment of gasoline motors is attributable to this cause. To a certain extent, the defect can be remedied by the regulation of the supplementary air supply to the carbureter, to insure more perfect carburetion, but there are a great number of cars not equipped with this means of combating the evil. Taken on the whole, engines balanced to run at high velocities should not be supplied with motor spirit the specific gravity of which is greater than 0.700; and the nearer the density approaches 0.685, the greater will be the power developed by the engine. In the cases of slow-running engines, the difference is not emphasized to such a degree.

Some automobilists who have experienced difficulty in this connection have sought to increase the dynamic force of the motor spirit by the addition of picric acid, ether, and similar inflammable and highly volatile gases. This expedient, however, while being attended with certain augmented risks concerning explosion, exercises a deleterious effect upon the engine. For instance, picric acid will form a deposit in the carbureter, not only corrosive in character, but which will also in a short time choke the holes of the spray and thus seriously impede vaporization of the spirit, thus necessitating more frequent cleaning of the carbureter. Thus the remedy becomes worse than the disease, unless extreme care and attention are exercised.

SEPARATION OF THE HIGHER ACIDS OF PEANUT OIL.*

WITHOUT taking part with any of the writers as to the value of the method proposed by M. Jean, to replace that of Renard for the separation of arachidic acid, it may be affirmed that the latter, which has rendered and still renders very great service, has a very serious disadvantage, which manifests itself in the filtration and washing of the lead soaps by means of ether. These form a glutinous mass, whose rapid evaporation of the solvent renders the washing long and troublesome.

I have not verified the fact whether potassium arachidate is insoluble in alcohol in presence of an excess of alkali, but knowing that the acid salts of the solid fatty acids, and in particular the acid salts of arachidic acid, are less soluble in alcohol than the neutral salts, I concluded that this property would permit the easy preparation of this characteristic body.

The operation is effected in the following manner, for which a larger quantity of material may be employed than in the Renard process.

The oil is saponified and the fatty acids separated in the usual manner; then these last are dissolved in 90 deg. alcohol. A definite volume is divided into two equal parts, of which one is exactly saturated, hot, with potassium in presence of phthalein. By adding to this neutralized portion the other half of the solution and letting it cool to 40 deg., the soap is precipitated in the crystalline state. After standing some time, it is placed on a hardened paper filter, which is fastened to the blowing apparatus. The precipitate is redissolved, hot, in 90 deg. alcohol and again filtered after standing some time in the cold. The acid salt is dried between folds of paper. Then it is suspended in water, decomposed with chlorhydric acid, and washed, first with distilled water, then with 70 deg. alcohol repeatedly, for the purpose of dissolving the palmitic and stearic acids. Finally, an acid melting at about 70 deg. is obtained.

The great advantage of this process consists in this, that the precipitate of the acid soap, being crystalline, filters and washes very well, and in the fact that its solubility in alcohol is less than that of a neutral salt, or than that of acids at a less elevated fusing point.

This method, however, does not appear capable of being used for the separation of various solid acids by employing alcohol of different degrees of concentration.

SUGAR TRUST CAPITALIZATION.

WHAT H. O. HAVEMEYER SAYS OF IT.

THOUGH the capital stock of all the companies it banded together aggregated only about $6,590,000, it organized itself on a basis of $50,000,000. Now one of the especial dangers of trusts is a tendency toward over-capitalization—the selling of more shares to the public than can truly exist upon a basis of cash value. What did the additional forty-three and a half millions represent? Questions like that came from the government in course of formal inquiry.

"I am not able to see," remarked the government questioner, "how businesses that were not profitable before could increase in such a rapid way."

Mr. Havemeyer made it simple for him: "You and I are in business, and we run our business to suit ourselves. I say: 'Let us form a trust.' You say: 'No; I don't care to go in.' I go alone and put up the price of sugar a quarter of a cent, and that enables you to make a fair profit. Now I say to you: 'What do you want for your plant?' The plant is worth a million, but you won't sell to me for less than two millions. I can make more money by buying that plant for two millions under the advance of the price of sugar than I can by leaving you out (as a rival)."

All sugar-mills become more valuable because of conditions that were "about to prevail." Not alone the good-will and the possible earning capacity had to be paid for, but also the proprietary trade-marks, though they would seem to be included as part of the earning capacity. One of Mr. Havemeyer's sayings is: "I would rather have a celebrated trade-mark than a million-dollar plant."

He gives an illustrative incident:

"When refineries outside the trust were struggling for business, and the Arbuckles started in to fight me, I telegraphed to the trust refineries in New Orleans, Boston, and Philadelphia to 'put the Havemeyer & Elder stencil on each barrel of sugar;' and they did, and people would not buy other sugar when Havemeyer sugar could be had at the same price. Our sales jumped a third at once. Arbuckle then had to sell at ten cents off."—The Century.

FLEXIBILITY OF COATS OF VARNISH AND PIGMENTS.

IT is well known that these coats often need to possess considerable elasticity, to enable them to follow deformations of the surface below them without cracking. This is, of course, particularly necessary on a flexible material, such as leather or oilcloth.

Most coats are flexible enough when only just dry. The brittlest spirit varnish can be applied to paper, which can then be folded as soon as the varnish is dry, without cracking, but a few days afterward it will split if the paper is only slightly bent. Every oil varnish has this elasticity when only just dry, but loses it as soon almost as spirit-varnishes. As a matter of fact, all the varnishes are not absolutely dry when they still retain their pliability. The last traces of the solvents employed in their manufacture disappear rather slowly, and as long as they are present the coat remains elastic. Again, linseed oil keeps a varnish longer pliable than a volatile solvent does, but just as the latter evaporates, the linseed oil oxidizes and becomes resinous and brittle. The thinner the coat, too, the better. Hence, for metallic capsules which are stamped out of sheets previously painted and varnished, those colors are chosen which have the most body, so that the coating may be as thin as possible, and that one coat may be enough. The stamping must, of course, be done directly the paint and varnish appear dry. When we consider that only spirit-varnishes are used for capsules, the success achieved by using very thin coats is sufficiently striking. With thick metal, a varnish can be applied which will stretch where the metal is stretched with deformation, but one has yet to be invented that will conform to the depressions in the metal. Here all known varnishes crack and peel off.—Farben und Lack Zeitung.

* Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from the French of M. G. Perrin in the Moniteur Scientifique.

LUMINOUS BUOYS.

As useful as the lights that illuminate the coasts may be, whether lighthouses, lightships, or buoys, it is self-evident that economy is necessary in the matter, and the more so in that these different lights are extremely numerous, even upon quite a limited extent of coast. So competent men in the lighthouse service are always trying to invent devices capable of operating automatically day after day, in order that it shall not be necessary to pay a number of persons to watch and feed them. It is in such a spirit that the French Lighthouse Service has established some lightships designed to operate without keepers. On the other hand, in the number of small lighthouses, of isolated lights in alignment, and of lighthouses constructed more or less in the open sea and that are often not easy to reach in order to clean the lighting apparatus, it was likewise necessary to find a combination of light capable of burning for several months without a keeper. Such a result has been attained by the use of petroleum, along with a wick upon which is deposited, before putting it in service, a regular layer of carbonized tar.

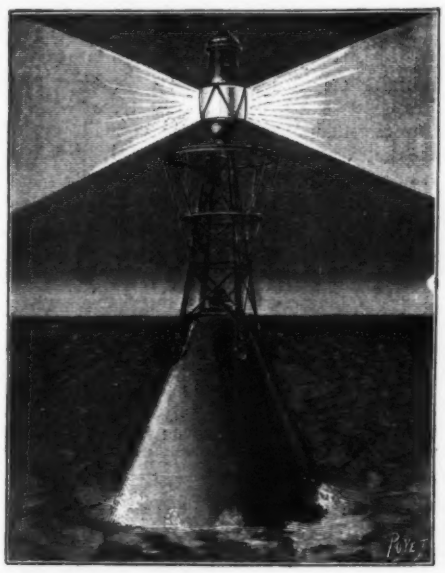


FIG. 1.—A LUMINOUS BUOY LIGHTED.

The vaporization of the oil takes places laterally, outside of the parts where the deposits of tar produced by combustion accumulate, and the flame is capable of keeping up for a long time without such accumulation introducing any perceptible modifications in its operation. The same object has been aimed at in buoys, the form of which, moreover, has been experimented with to at least as great an extent as the mode of lighting, since it is necessary to give them sufficient stability to prevent them from oscillating too violently when rocked by the waves, as this would have the effect of almost constantly masking the light that they carry at their summit. In principle, the light adopted is furnished by oil gas, manufactured and compressed according to the Pintsch process.

At certain points buoys of this kind have been substituted for lightships, though not for lights marking important alignments, but for others designed for signaling dangers that navigation is obliged to steer clear of. In such a case, it is even possible to put several buoys in place of a single boat, and, consequently, to fix the limits of the rock to be avoided, instead of simply indicating its approximate center; and this can be done, too, with considerably less expense. We have no intention of describing the various luminous buoys placed in this way upon the French coast, but shall speak only of the two large 530 cubic foot ones which have been anchored upon the plateau of Rochebonne off the coast of Vendée, and which carry, at 26 feet above the loadwater line, a stationary light apparatus of 7.5 inches focal distance and of a power of 40 carcels. These buoys are anchored in water 165 feet deep, and are stable in all kinds of weather. Moreover, if we examine their form, we shall see that they are provided beneath with a cylinder which prolongs the float and permits of placing, at 26 feet below the loadwater line, a ballast that lowers the center of gravity beneath the center of the cylinder and therefore assures an almost perfect stability. Consequently, under the influence of the waves, they undergo only vertical motions of emersion and submersion, and their light appears effectively stationary instead of exhibiting the periodical occultations of the ordinary buoys submitted to the action of rolling. With duplex gas burners the consumption is 4.25 cubic feet an hour. Some of these buoys have a carrying power sufficient to support 7,700 pounds of anchoring chain, and are consequently capable of being anchored in very deep water without their stability being thereby affected. Let us add that the cost of the first establishment of a large buoy, capable of replacing a lightship, is about $6 per cubic foot, and that the annual cost of maintenance appears never to exceed $400, while the cost of the first establishment of a lightship is something like $1,715 per cubic foot, and the annual cost of maintenance $8,000.

Luminous buoys are becoming more and more employed by the French Lighthouse Service, notably on the Maritime Seine for the tortuous and shifting channels that are met with in the estuaries of the river. Here, of course, there is no longer any need of giving them a great luminous range.—Translated from La Nature for the SCIENTIFIC AMERICAN SUPPLEMENT.

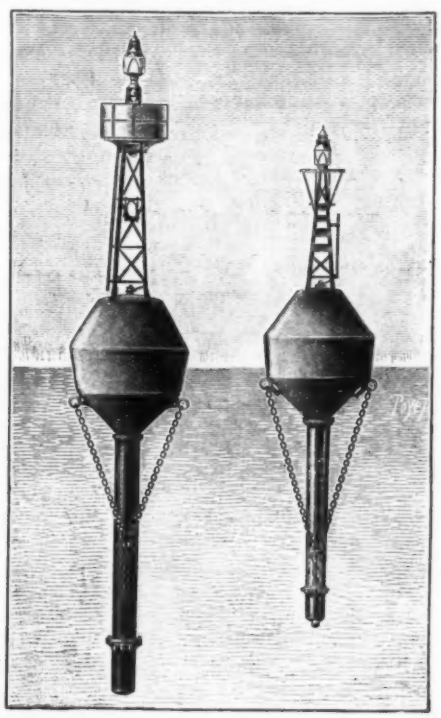


FIG. 2.—TWO TYPES OF LUMINOUS BUOYS.

EXPERIMENTS OF M. MOISSAN.

M. HENRI MOISSAN has lately succeeded in producing fluorine in the solid state, by means of the intense cold obtained by liquid hydrogen. Several years ago M. Moissan first produced gaseous fluorine by means of an electrolytic apparatus and then showed that the gas liquefied at —187 deg. C. Since Prof. Dewar succeeded in producing liquid hydrogen, boiling at —252.5 deg., or at 20.5 deg. from the absolute zero, the cold which was thus reached enabled the experiment upon the liquefaction of fluorine to be carried out more easily, and the work was taken up a short time ago. Since the first experiments it was found that fluorine which was quite free from hydrofluoric acid did not attack glass at the ordinary temperature and so the gas could be contained in a glass vessel with thin walls and submitted to the intense cold produced by the liquid hydrogen. The gaseous fluorine could not be condensed by using liquid oxygen, but when a sealed tube full of the gas was placed in a double-walled vessel full of liquid hydrogen, the gas was observed to condense into a yellow liquid. The liquid takes the gaseous state again when the tube is drawn out of the vessel. Upon replacing the tube the fluorine condenses again to a liquid and the latter then assumes the solid state.

This is the first time, therefore, that solid fluorine has been produced. By plunging the tube completely into the liquid hydrogen and allowing it to reach the temperature of 20.5 deg. (absolute), it was found that the solid fluorine, which was yellow at first, now became white. This phenomenon is the same as that which is furnished by chlorine, bromine and sulphur. At a very low temperature a certain number of bodies lose their color and become white. By placing the fluorine in liquid nitrogen it is demonstrated that it remains still in the liquid state at —210 deg. C. The comparison was then made between the melting points of solid oxygen and solid fluorine as follows: The end of the sealed tube containing the fluorine was placed in a small glass cylinder full of liquid oxygen and the whole placed in the liquid hydrogen. The oxygen and the fluorine are both solidified. The tubes are withdrawn slowly from the liquid hydrogen and both the bodies commence to melt. The oxygen, however, becomes melted while the fluorine is still solid, and thus the melting point of fluorine is below that of oxygen, which is 38 deg. above absolute zero. By repeated experiments it is shown that the melting point of solid fluorine is about 40 deg. absolute or —223 deg. C.

Another point brought out in the experiments is the question of chemical affinity at these low temperatures. It is supposed that at the absolute zero, matter is inert and chemical affinity no longer exists. It was of interest therefore to see whether solid fluorine kept at 20.5 deg. above absolute zero (or —252.5 deg. C.), would react upon liquid hydrogen, and if the fluorine would

continue to combine with bodies with its accustomed energy.

To carry out the experiment a thin glass tube is used containing 40 c. c. of gaseous fluorine. It was completely solidified in one of the pointed ends of the tube and the latter was then placed in a considerable volume of liquid hydrogen. When its temperature reached that of the hydrogen, the point of the tube was broken so as to make contact between the solid fluorine and the liquid hydrogen. A violent explosion is at once produced, setting free such a great quantity of heat that the matter was brought to incandescence and the hydrogen took fire. The explosion was strong enough to reduce to powder the glass tube and the vessel containing the hydrogen. This very significant experiment shows that for energetic reactions such as that of fluorine upon hydrogen, the affinity is maintained at very low temperatures and that certain combinations can still be produced within 20 degrees of the absolute zero. The solidification of fluorine is therefore to be added to the previous work in this line, and at present helium is the only gas which has not been brought to the solid state.

A CONSIDERATION OF PHOSPHORESCENT AND FLUORESCENT SUBSTANCES.*

By WILLIAM J. HAMMER.

SIR GEORGE STOKES has given the name of "fluorescence" to the phenomena which certain substances present in altering the very short waves of ultra-violet light, which are invisible, and transforming them into waves of longer length so that they become visible to our eyes.

In electrical parlance a fluorescent substance might be termed a step-down transformer or perhaps more correctly a frequency change for light waves. Stokes, as a result of his investigations, framed this law: "When the refrangibility of light is changed by fluorescence it is always lowered and never raised"—in other words, the waves emitted during fluorescence are always longer than those which are absorbed, thus causing fluorescence. There are, in fact, cases where the frequency of the radiations is increased; but where there is such an exception to Stokes' law some sort of chemical reaction occurs.

The lowering of the frequency of certain ultra-violet radiations, so as to render them visible, was known to Brewster in 1833 and Herschel in 1848, the former terming it internal and the latter surface dispersion; but it was first explained and the name given to it by Stokes in 1852, after a form of fluorspar.

In the case of fluorescence, the emission of the light lasts only so long as the substance is stimulated by the incident beam; but in the case of the phosphorescence, the emission of light continues or persists after the stimulation has ceased, or the original source has been removed. The word phosphorescence is from the Greek "phosphoros," meaning light bearer.

Prof. E. Wiedemann has suggested the name "luminescence," to cover fluorescence, phosphorescence, and phenomena of that character possessed by many substances whose light emissions are unaccompanied by flame or by the temperature of ordinary light waves; but this term can hardly be made to cover the Becquerel rays emitting from radioactive substances.

I have here to-night a collection of tubes containing fluorescent liquids, such as petroleum, quinine, Magdala red, eosine, uranine, saffronine, paviine, æsculine, amidophthalic acid, fluorescine, rhodamin, etc., . . . all of which show most beautiful changes in color when viewed by direct and transmitted light.

I also have some of the fluorescent hydrocarbon "thalleen," prepared by the late Prof. Henry Morton, and some of those most beautiful fluorescent substances, resorcorufin and resorcin blue, for which I am indebted to Dr. Geyer of Stevens Institute. Fluorescent substances are particularly beautiful in the ultra-violet light; for instance: The yellow fluorescence becomes a most beautiful green; the orange colored eosine becomes gamboge; the crimson color of Magdala red a bright scarlet; the straw colored æsculine becomes a pale blue; the transparent and colorless quinine gives its characteristic blue surface tint; the paraffin oil a beautiful blue; and the various other substances giving a beautiful surface color quite different from that of the interior of the solution.

Small pieces of horse-chestnut bark or bark of the ash tree placed in a dilute ammoniacal solution produce a most beautiful fluorescent effect, as the dyeing material descends slowly through the liquid.

Flowers painted with these fluorescent substances on cardbroad produce a most beautiful effect when light screened by dark blue or violet glass is thrown upon them.

Sodium vapor fluoresces brilliantly in sunlight.

I also have here samples of tungstate of calcium, platino-barium cyanide, sulphide of zinc, and similar preparations which have been extensively used in the fluorescent screens for X-ray work.

Here is a specimen of willemite which when exposed to the ultra-violet light produced by the bright snappy condenser spark between these iron electrodes shows a magnificent fluorescence.

Here is a card with the words written with a solution of platino barium cyanide which fluoresces beautifully when exposed to the ultra-violet light of the iron arc, especially when shielded by the accompanying colored glass plates.

I have also one of Prof. R. W. Wood's interesting ultra-violet screens, consisting of four plates of cobalt glass between which are gelatine films containing nitroso-dimethyl-aniline with copper oxide, which screen when employed in front of the arc lamp renders beautifully fluorescent a lump of uranium nitrate held in the focus of the invisible rays.

Through the courtesy of Dr. Von Recklinghausen, I am enabled to show you a Cooper-Hewitt tube which is inclosed in a screen soaked in rhodamin, the best substance which thus far has been found which is fluorescent in the light of the mercury arc.

* Abstract of lecture delivered before a joint meeting of the Amer. Inst. of Electrical Engineers and the Amer. Chemical Society.

It is well known that many bodies become red-hot at a temperature of between four and five hundred degrees Centigrade, and to make them white-hot a temperature of between eight hundred and a thousand degrees is necessary; but there are many substances which are phosphorescent and which possess the property of giving off considerable light without sensible heat.

I have here some samples of two phosphorescent substances which have been known for many years—one of them a sulphide of barium or Bolonese phosphorus, and the other a sulphide of calcium or Canton's phosphorus. The former was discovered in 1602 by Casciario, a shoemaker in the city of Bologna who prepared it by the partial calcination of a certain powdered heavy spar mixed with a little flour meal, which he roasted in the furnace; and found afterward that when exposed to sunlight it would shine in the dark. This preparation was succeeded by the discovery of John Canton, who calcined oyster shells with charcoal and meal in a closed crucible, thus producing a brilliant phosphorescent substance called after his name.

Phosphorescence by insolation—or exposure to sunlight—has been extensively investigated by Profs. A. E. Becquerel and J. W. Draper.

Practically all substances in nature are phosphorescent, and although some of them remain phosphorescent for only one ten-thousandth of a second, others retain their phosphorescence for hours.

One may expose sulphide of calcium to sunlight, and after placing it in a dark room for six weeks it will still affect a photograph plate.

Phosphorescence may be stimulated in many ways—by combustion, pounding, rending, friction, by the vibrations from sources of heat, light, or electricity; and these various phosphorescent substances are very susceptible to temperature changes.

Various substances also phosphoresce while undergoing crystallization.

I have here a large sheet of cardboard which has been prepared for me by Messrs. Devoe & Co., which is covered with seven coats of Balmain's luminous paint or poly-sulphide of calcium, with perhaps a trace of bismuth, and mixed with aerated varnish; and it has been put through hot calender rollers. You will note that this phosphoresces most beautifully when excited by burning this piece of magnesium wire before it, or by focusing the arc light upon it. This phosphorescence soon dies out, however; but upon placing my hand against the sheet, the heat of my hand has caused the card to brilliantly phosphoresce. A cold object placed against the cardboard will very much lessen the phosphorescence at that point.

When I place this bust of Franklin between the arc light and the phosphorescent cardboard, you will note I can thus produce a fine silhouette of that distinguished philosopher.

I have prepared for your consideration a number of objects coated with phosphorescent substances. When I burn this piece of magnesium wire in front of this card, or hold it before the arc light, you will note the initials of the A. I. E. E. and the A. C. S., the two societies before which I have the honor of appearing to-night, shine out brightly. I also have a number of incandescent lamp bulbs, coated internally and externally with phosphorescent substances, which you will note give considerable light when stimulated by the burning magnesium; or by turning on the electricity supplying certain of the lamps.

I remember nearly twenty years ago having cut out tiny stars from cardboard and painted them with luminous paint, and arranged them on the ceiling of my bedroom to represent certain of the principal constellations in the heavens. These stars would absorb the light during the day time, and at night would represent an appearance as though the roof had been removed and one was looking at the stars in the sky.

I have here a philosophical toy which I made years ago, with which I can show the varying phases of the moon. I have taken a 25-cent globe, and painted half of it with black japan, as representing the dark side of the moon which is never seen, the other half I have painted with a number of coats of luminous paint; and by exciting the phosphorescence of this half by the burning magnesium, you will see that by slowly turning the globe around, a perfect representation of the varying phases of the moon occurs.

I hold in my hand here a long tube coated inside with sulphide of calcium, which makes a beautiful wand, which an orchestra leader might use in a dark scene. I remember years ago fixing up a vacuum tube and coil for use as a baton in the dark scene in Gilbert & Sullivan's opera of Ruddigore, and fearing lest the complaisant leader be some day knocked off his stool by the 8-inch coil.

Here are a couple of postal cards which I secured in Europe showing the Blue Grotto at Capri. They are printed with phosphorescent paints; and on exposing them to the light, you will see they are exceedingly pretty.

Prof. Dewar has shown that eggshells, feathers, ivory, and paper become brilliantly phosphorescent if they are cooled to about 200 degrees below zero by use of liquid air, and then exposed to light. Many bodies seem to possess this power of absorbing energy at low temperatures and giving off light at higher temperatures. In fact, Dewar has observed that at a temperature approximately that of the boiling point of oxygen (184 deg. C.) all bodies, even living tissues, become phosphorescent.

I have here a collection of forty or more glass tubes containing various phosphorescent substances which, when I burn this magnesium before them, you will note become brilliantly phosphorescent, showing red, yellow, green, blue, and in fact, all the colors of the spectrum. The sulphides of calcium, barium, strontium, zinc, etc., largely enter into their composition. I also have here some fine particles of fluorspar, which, when scattered on this hot plate, glisten like fireflies.

A similar effect may be produced by quinia or its sulphate which when spread on a sheet of paper and laid on a hot metal plate in a dark room, shows a remarkable phosphorescence which develops at the edges and spreads to the center.

Boracic acid fused and allowed to cool breaks into small pieces, and along the cracks prosphorescent light appears. Potassium sulphide fused with cream of tartar shows the same phenomenon.

Phosphorescent ether may be prepared by digesting phosphorus in ether for some days in a tightly-corked bottle, and when a lump of sugar is dipped into this and dropped into a glass of water, the surface appears quite luminous.

The stream of particles, so thoroughly investigated by Prof. Crookes, was given the name of "cathode rays" by the Germans, as a protest against Crookes' theory of molecular streams propounded by him at the British Association meeting in 1879; Lord Kelvin has told us that the smallest particle which can be observed by the most powerful microscope contains 18 to 20 million atoms, and although until recently the smallest particle we could conceive of was the atom of hydrogen, this being the lightest of gases, Prof. J. J. Thomson has now shown us that these atoms may constitute a thousand fragments, or as he calls them, "corpuscles," and Crookes showed us, and Villard of Paris recently demonstrated conclusively that the cathode rays consist of a stream of these hydrogen corpuscles negatively charged and moving at a speed approximating 70,000 miles per second; and as illustrating the complexity of an atom, I am reminded by Prof. Hallock that the late Prof. Henry Rowland once said that a Steinway grand piano was a comparatively simple piece of mechanism compared with an iron atom.

Prof. Crookes has shown many notable experiments in which substances have been caused to phosphoresce inside of the Crookes tube by the molecular bombardment of "cathode rays"; and I have here some fine Crookes tubes containing red and white coral, rubies, calcite, lava, etc., which you will note phosphoresce finely. (I am indebted to Messrs. Queen & Co. for certain of these.)

Prof. Crookes has made a diamond so phosphorescent inside of a Crookes tube as to give a full candle-power of light. Rubies, emeralds, corals, fluorspar, lime and many other substances similarly phosphoresce in the Crookes tube.

I have here a Crookes tube containing calcined seashells, which, on connecting to the induction coil, is caused to give off a most brilliant light, and the globe and contents to phosphoresce long after the current is shut off.

Here again I have a tube containing four separately exhausted sections, which are filled with phosphorescent substances, and a tiny tube passing through all of the partitions of the tubes, and being connected with the electrodes at the end. On connecting this to the induction coil a luminous gaseous stream is seen in the tiny tube, and the discharge accompanying it affects powerfully the phosphorescent substances which, you will note, are colored green, yellow, and blue, after the current is shut off.

I have here also a Crookes "radiometer," the vanes of which are painted with phosphorescent substances, and on connecting the radiometer to the coil the electricity rotates the vanes and causes them to become highly phosphorescent.

At a meeting of the Institute on January 3, 1902, through the courtesy of Mr. Edison, I was enabled to present some of Mr. Edison's tungstate-of-calcium lamps which have sometimes been called Edison X-ray lamps. These lamps were Crookes tubes, the interior walls of which were coated with fused crystals of tungstate of calcium, which were caused to phosphoresce most dazzlingly when they were connected to an induction coil. Through an accident to my large coil, I was unable to show these tubes working as perfectly as I should have liked; and to-night I will show you as an evidence of good faith some of them operating as they should operate, and giving a most powerful light. Incidentally, I am going to show you that this cannot properly be called an X-ray lamp, although a form of X-ray tube is employed, as it is not the X-rays outside but the cathode rays inside of the tube which produce the phosphorescence. This tube which I have here and which I have coated with tungstate of calcium and platino-barium-cyanide on the outside, I will now place underneath an ordinary Crookes tube, that it may be exposed to the X or Roentgen rays; and you will see that while the coated surface fluoresces, as any fluorescent screen will when exposed to Roentgen rays, the moment these rays cease there is absolutely no phosphorescent effect, there being no persistence of the luminescence.

Now, another thing which I think I can show you is that, while cathode rays produce by their action on the interior wall of the glass tube a secondary effect or ether pulsations on the exterior which are Roentgen or X-rays, I can now produce the converse of this by bombarding the outside of the Edison tube by the Roentgen rays from the Crookes tube, as you will see then that I have caused cathode rays to be stimulated in the interior of the tube which is merely held near it, causing the tungstate of calcium to become brightly phosphorescent; and you will note that I can deflect the cathode rays with a magnet. I believe this is the first time this conversion of Roentgen rays into cathode rays has been accomplished and is rendered possible by this form of tube.

There are many commercial applications which may be made of this curious property of phosphorescence. Life buoys have been painted that they may be seen when thrown overboard; sheets of cardboard, such as I have shown you, have been used to give light in powder magazines. I have also suggested the painting of projectiles with phosphorescent substances for use at night in war times. Phosphorescent clock and watch dials have been made in large numbers, and it has been suggested to make house numbers, door knobs and escutcheons for key holes of such materials, cover the walls with luminous paper, and even paint the houses with luminous paint.

The taps or keys of incandescent lamp sockets and switches might be made of glass containing phosphorescent material, or the cases painted as I have here done, so that they could readily be seen in the dark; and doubtless certain phosphorescent substances might be used to considerable advantage in connection with various types of vacuum tube lighting and for

vacuum tubes used in connection with wireless telegraphy.

I hold in my hand a tiny tube which I secured in Paris, which contains what is perhaps one of the most brilliant phosphorescent substances that has yet been discovered. It is a special preparation of sulphide of zinc. Here is a second tube containing some of the sulphide of zinc, which also has mixed with it some radium.

A tube of this mixture may be put away in the dark for years, and the radium will act on the zinc, causing it to phosphoresce brilliantly.

Who will say that we shall not some day find a substance which will be so powerfully acted upon by the emanations from radium that it may be used as a source of light?

Here I have a tube which I have made on the suggestion of Prof. Curie, consisting of two bulbs with a stopcock between, in one of which may be placed sulphide of zinc, or similar substances, and in the other radium; and in this manner the radioactivity of various substances may thus be investigated.

A tube containing chloride or bromide of silicon and exhausted to 12 or 15 mm., and sealed, will when rubbed briskly with silk glow in one case a rose color and in the latter a greenish yellow.

I hold in my hand here two Geisler tubes, each containing an inner tube with beaded surfaces. In each of the outer tubes is a small amount of quicksilver; and in one tube nitrogen gas, and in the other carbonic acid gas. By shaking these tubes rapidly the friction of the quicksilver against the glass produces electricity, which causes the gas to become luminescent. Various other gases may be thus employed, producing different color effects.

It has been suggested that life buoys could be equipped with a number of mercury tubes, circular or otherwise, and set in different positions, so that the rolling of the buoy in the sea would constantly agitate the mercury and render the tubes luminous.

Here is a tube containing mercurial salts, which changes greatly the color of its phosphorescence by heating the tube in alcohol flame.

In this box I have a large spiral glass tube which is expanded into bulbs at various points throughout its length. This tube, for which I am indebted to my friend, Dr. Geyer, contains sulphuric anhydride; and you will note when I connect this to the induction coil and send a discharge of electricity through it that the gas inside of the tube becomes phosphorescent and remains so for a considerable period after the electricity is cut off.

I have here a bottle containing phosphorus and olive oil, which you will see becomes most brilliantly phosphorescent when I withdraw the stopper, and allow the air to enter the bottle. The phosphorescence in this case is due to combustion, or to the oxidation of the liquid. I can also write phosphorescent characters on this ground glass plate wet in hot water with this stick of phosphorus. Other forms of phosphorescence are caused by chemical changes or the slow combustion of decaying vegetable matter or decaying fish.

Occasionally clouds show a phosphorescent light at night; snow is phosphorescent after exposure to sunlight, and no doubt many substances retain during the night the phosphorescent light imparted by the sun's rays during the day.

There are also many insects, such as fireflies and glowworms, and many deep-sea fishes which have the properties of producing phosphorescence. Phosphorescence is exhibited among other animals by the infusorian noctiluca, marine radiates, polyps, etc., which are the principal causes of phosphorescence of the sea.

The tropical beetle *Pyrophorus noctilucus* has been most carefully studied by Prof. S. P. Langley and F. W. Very, and the efficiency of the light given off tested by the Langley bolometer; and they have demonstrated that practically all the energy which its phosphorescence represents, appears as light; and the light given off by this insect is the most efficient light known, it being produced at about one four-hundredth part of the cost of the energy which is expended in the candle flame.*

Sir Oliver Lodge says if the secret of the firefly were known, a boy turning a crank could furnish sufficient energy to light an entire electric circuit.

And Prof. Langley says, "There seems to be no reason why we are forbidden to hope that we may yet discover a method (since such a one certainly exists and is in use on a small scale) of obtaining an enormously greater result than we now do from our present means of producing light."

Langley believes the light of these insects is due to chemical action, as it is decreased by nitrogen, which checks combustion, and is increased by oxygen, which increases combustion, and furthermore, the product is apparently carbon dioxide.

We also may produce phosphorescence by rubbing crystals together, or by friction of other bodies, or by cleavage, such as fracture of lump sugar in the dark.

Among plants, phosphorescence was first recorded by A. Linnæus, whose daughter discovered it in the nasturtium. Phosphorescence or flashes of light are often observed in the common red and yellow marigold, the tuberose, sunflower, poke weed, martagon-lily, the poppy, the root stock of khus-khus grass, and the sap of certain tropical vines and subterranean plants, in some liverworts, ferns, mosses, fungi and algæ, and the mycellum of fungi in decaying wood. This phosphorescence is said to be due to slow decay and oxidation, either in the mycelia or fructifications of the fungi. Heat and dryness soon dissipate it.

* "On the Cheapest Form of Light," by S. P. Langley and F. W. Very, No. 1358 Smithsonian Misc. Coll.

JUPITER AND HIS GREAT RED SPOT.

THOUGH Jupiter has been unfavorably placed for European observers during the present year, his surface markings have been extremely interesting, of great variety and in plentiful numbers. The English climate, even at its best, can scarcely be said to suit astronomical work in an eminent degree, but its characteristics in 1902 have proved unusually bad; in fact, atmospheric conditions have combined with the low position of the planet to render observations difficult, and they have generally had to be pursued with definition of very inferior quality. The seeing has been recorded as "very good" on six nights only out of seventy-five, and in 1901 the result was equally disappointing, for the image was really sharp and satisfactory on five nights only out of seventy-one; but in 1901 the planet was about 5 deg. lower (Dec. 23 deg. S.) than in 1902 (Dec. 18 deg. S.), and though the difference is not great, it ought to have operated strongly in favor of the present year had other circumstances been equal.

The most noteworthy incident in connection with recent studies of Jupiter is to be found in a very pronounced acceleration of motion in the great red spot. This first made itself evident in 1901, but it has been intensified during the past summer. For about twenty-three years, uninterruptedly, this singular marking had exhibited a constantly increasing retardation, which caused its rotation period to lengthen from about 9h. 55m. 34s. to nearly 9h. 55m. 42s. But in 1901 it declined to 9h. 55m. 41s., and during the present year the rate has been about 9h. 55m. 39½s. And this increase of velocity has been contemporary with the outbreak of a large, irregular or multiple marking of a dusky hue, in the same latitude of the planet. This new object, apparently first seen in May, 1901, has shown a rotation period of 9h. 55m. 18s., which corresponds with that of the south temperate current. It seems a probable conjecture that the presence of the marking just referred to may have forced the red spot along at a more rapid rate than that which it exhibited in previous years. In June, July and August of the present year, the red spot was almost surrounded by the material of the new marking, and the quicker motion of the latter may well have accelerated the movement of the former. But no certain conclusion can be arrived at, though the facts are significant and suggestive. Possibly the phenomena alluded to may have been practically coincident in date, but devoid of any physical relationship. And in this connection it will be useful to remember that the red spot has always been situated in a stream flowing along with much greater celerity than the rate of its own motion.

In September, the material of the new marking had passed to the preceding (W.) side of the red spot, and hence it was expected that the accelerated motion of the latter would cease, but the differences in motion have been comparatively slight, so that errors of observation make it unsafe to form definite conclusions. It will be advisable when the planet disappears from the evening sky in January next to collect all the transit times of the red spot recorded during the present apparition, as it may then be possible to determine with accuracy the extent of the acceleration and the variation in its rate, if any, during the summer and autumn. If a large number of observations are forthcoming, it will be desirable to group them into monthly or bi-monthly periods and ascertain the mean longitude of the spot for each of these, when the rate of its drift will be seen and the errors of individual transits practically obliterated.

At Bristol, the following estimated transits have been obtained with a 10-inch reflector and a power of 312:

Date. 1902.	G.M.T. h. m.	Longitude. deg.
April 28	16 14	45.9
May 20	14 23	44.7
June 20	14 56	44.8
June 27	15 37	42.2
July 2	14 49	45.1
July 7	13 54	43.9
July 9	15 33	44.5
Aug. 8	10 8	40.2
Aug. 12	13 29	41.7
Aug. 15	10 57	42.5
Aug. 20	10 3	41.7
Aug. 25	9 7	39.6
Sept. 1	9 50	38.0
Sept. 13	9 48	40.3
Sept. 18	8 56½	40.5
Sept. 28	7 9	37.9
Oct. 3	6 18	37.9
Oct. 10	7 9	40.2
Oct. 15	6 13	37.1
Oct. 22	7 1	37.1
Nov. 8	6 8	36.9
Nov. 18	4 31½	39.4
Nov. 23	3 36	36.1
Nov. 25	5 20	39.1

During the present year, a number of white and dark spots have been visible on the north side of the north equatorial belt, and the mean rotation period of these has been about ten seconds less than that shown by the red spot. A new belt has lately formed on the northern side of the spots alluded to. The equatorial current of the planet has been moving, as nearly as possible, at the same rate as during 1901, for the mean rotation of twenty-four spots is about 9h. 50m. 29s. There has been an abundance of slow-moving N. and N.N. temperate markings, but these have seldom been well seen owing to the confused definition.—W. F. Denning in Nature.

INSECTICIDES.

INSECTICIDES may be discussed under three chief headings—powders, pastes, and liquids. Let us consider them separately.

Taking up

POWDERS

first, we may consider a few formulas and then from them choose one for our special brand. The ordinary insect powder on the market is made from Pyrethrum carneum, Pyrethrum roseum, and Pyrethrum cinerariæfolium. The first two are generally ground together and are commercially called Persian insect powder; while the third is commonly called Dalmatian insect powder. These powders are sold in the store under many names and are in every case held up to be the best—better than is furnished at any other store. They are also sold in combination with other powders under some proprietary name, and in this form can be made to yield a good margin of profit to the dealer. The following formulæ are all good ones and perfectly safe to use. In each instance insect powder relates to either one of the pyrethrum plants powdered, or to them altogether:

(1) Insect powder ..... 8 ozs. av.
Powdered borax ..... 8 ozs. av.
Oil of pennyroyal ..... 2 fl. drachms

(2) Insect powder ..... 8 ozs. av.
Borax ..... 8 ozs. av.
Sulphur ..... 4 ozs. av.
Oil of eucalyptus ..... 2 fl. drachms

This formula is especially good for cockroaches:

(3) Insect powder ..... 14 ozs. av.
Quassia, in fine powder ..... 6 ozs. av.
White hellebore, powdered ..... 2 ozs. av.

PACKAGE FOR THE POWDER.

Any one of these powders will prove efficacious, and you can choose for yourself which one to use, resting assured that if you will only take the question in earnest, and work at it with a will, the results cannot be anything else but favorable to you. Assuming that you have selected your formula, the question arises, How shall I put the preparation on the market? There will be no trouble about the package, for you can get all the lithographed cans with double covers that you want at a very small cost. To be sure, you need your name and brand on the can, and you must as well have a little paragraph on the back of the can extolling the merit of the substance within. A legend like this would be appropriate: "This powder is especially adapted to the extermination of bedbugs, cockroaches, and other house vermin of like character. In cleaning bedsteads, the cure will be most effectual if the powder is well applied after a good scrubbing with soap and water."

PASTES.

Let us now turn our attention to pastes. It is desirable to have something different from a powder, and a paste suggests itself. For the basis let us use common soap made into a jelly with sufficient water, and then we can add various combinations of strong poisons or drugs that are less active. Some housewives are very partial to corrosive sublimate for bedbugs in particular and other bugs in general. Well, we know that corrosive sublimate does not kill the festive bedbug unless the bug eats the poison. The corrosive sublimate cannot penetrate the waxy coat with which this disgusting bed-fellow is covered. But inasmuch as people insist on having this chemical, we can combine it with our paste as follows:

Common soap ..... 1 oz. av.
Ammonium chloride ..... 3 ozs. av.
Corrosive sublimate ..... 3 ozs. av.
Water, enough to make..... 32 fl. ozs.

Dissolve the salts in the water and add the soap.

This will make a paste that can be painted with a brush around in the cracks and crevices. Besides, it will make an excellent filling to keep the cracks of the wall and wainscoting free from bugs of all kinds. The formula could be modified so as to permit the use of Paris green or London purple, if desired. A decoction of quassia could be used to dissolve the soap. The latter paste would, of course, not be poisonous, and in many instances it would be preferred. You might make a cold infusion of white hellebore of 25 per cent strength, and in 1 quart of infusion dissolve 1 ounce of common soap. The advantage of the soap paste is simply to keep the poisonous substance thoroughly distributed throughout the mass at all times. The density of the paste can be varied to suit your own idea. Kerosene oil or turpentine could replace 6 ounces or 8 ounces of the water in making the paste, and either of these would make a valuable addition.

Another paste preparation which will meet with hearty recommendation is blue ointment. This ointment, mixed with turpentine or kerosene oil, can be used to good advantage; especially so as the turpentine is so penetrating that both it and the mercury have a chance to act more effectually. It can be said that turpentine will kill the bedbug if the two come in contact; and kerosene is not far behindhand in its deadly work.

Here are two formulæ which may be of use:

(1) Blue ointment ..... 1 ounce
Turpentine ..... 3 ounces

Stir well together.

(2) Blue ointment ..... 1 ounce
Kerosene oil ..... 3 ounces

Stir well together.

LIQUIDS.

Now let us consider the third division—liquid insecticides. There are even more liquids used than powders, and there is no doubt that the liquid form is the best to use; unlike a powder, or even a paste, it will follow down a crack into remote places where bugs hide, and will prevent their escape, and it will also kill the eggs and nits. In the long list of liquids used we find that the following substances are the most employed, and probably the best: kerosene, turpentine, benzine, carbolic acid, corrosive sublimate solution, oil pennyroyal, and strong solution of soap. Here are several good formulæ that can be depended upon:

(1) Oil of pennyroyal ..... 1 drachm
Turpentine ..... 8 ounces
Kerosene oil, enough to make..... 1 gallon

Put up in 8-ounce bottles as a bedbug exterminator.

(2) Oil of eucalyptus ..... 1 drachm
Eucalyptus leaves ..... 1 ounce
Benzine ..... 2 ounces
Turpentine ..... 2 ounces
Kerosene, enough to make.....16 ounces

Mix the turpentine, benzine, and kerosene oil, and macerate the eucalyptus leaves in it for twenty-four hours; then strain and make up the measure to 1 pint, having first added the oil of eucalyptus.

This is an excellent preparation for exterminating cockroaches. Take small bits of banana, or banana peels, and soak them in it, and at night put the bait around in places where the bugs frequent. Some are killed by eating the banana, and others are driven out. The cockroach is very fond of banana, and apparently

cannot resist the temptation even if the bait is poisoned.

(3) Kerosene oil ..... 8 ounces
Oil of wintergreen, a sufficient number of drops.

For bedbugs, you might modify the foregoing formula as follows:

(4) Oil of wintergreen ..... 2 drops
Benzine ..... 1 ounce
Turpentine ..... 2 ounces
Kerosene oil, enough to make..... 8 ounces

This combination beats anything I ever heard of for bedbugs. It will kill them by contact. The oils dissolve the wax coating of the bug and penetrate to its vitals. The other preparations mentioned are good and worth using, but to put up something that is effective and cheap, this formula cannot be beaten.

PACKAGES FOR PASTE AND LIQUID.

As for the packages, the liquid preparation must have a sprinkler top, which in the trade is commonly called a "bug top." This is fastened to each bottle, and is then inserted in place of the cork when the liquid is used. The most convenient package in which to dispense the paste is an 8-ounce amber bottle with a mouth large enough to freely insert a No. 3 painter's sash-tool. You can furnish a brush with a package or not, as you choose. To prevent any tampering with the contents of the bottle a neat paper bottle-cap would be practical and would add much to the appearance, and very little to the cost of the package. The label must bear the name of the preparation, and the directions for use. In writing the matter for the label, make sure to impress upon the purchaser the necessity of thoroughly washing the bedroom furniture and woodwork with plenty of soap and water before making a thorough application of the paste to all the cracks and crevices about the room and furniture; success can be guaranteed if this course is taken. Allow me to remind you of one particular point in getting rid of bugs of all kinds, a point that many a cleanly housewife does not thoroughly understand: a thorough use of soap and water about the woodwork and furniture of the house will often alone exterminate these household pests. Of course, it is not necessary, for obvious reasons, to tell your customers this.

Your liquid preparation is the one you must boast most of, and claim every merit for. Put it up in a bottle and sell for about 15 cents. A label bearing name and directions and your business address will be required. Give the following directions for use: "Shake the liquid into all the cracks and crevices where the bugs are likely to hide." You must not neglect to put a paper bottle-cap over the cork.—Bulletin of Pharmacy.

MANUFACTURE OF CEMENT FROM MARL AND CLAY.*

By HENRY S. SPACKMAN.

THE chemical elements necessary for the manufacture of Portland cement are lime, silica, and alumina, the last two being generally supplied by some form of clay or shale, the average ratio being one part clay to four parts carbonate of lime.

In the United States the lime used in the manufacture of Portland cement is found in several forms, which may be classified under three general groups—argillaceous limestone, marl, and limestone—the latter group being capable of considerable subdivision.

Considering these in the order of their relative importance in the cement industry, the argillaceous limestone is easily first, although its supremacy is threatened, the output decreasing from 72 per cent of the production of the United States in 1900 to about 61 per cent of the estimated production for 1903. The principal deposit of this material is found in eastern Pennsylvania and New Jersey. The most eastern development is at New Village, where the Edison Portland Cement Works are located. The Vulcanite and Alpha Works are a little south and nearer the Delaware River. The next development is at Nazareth, where a number of works are in operation and in course of construction, and the deposit can be traced across the country to the Lehigh River at Siegfried. Here are located the various works of the Coplay, Atlas, American, Lehigh, Lawrence, Whitehall, and Bonneville cement companies. There is no development of the deposit between here and the works of the Reading Cement Company at Molltown, which is probably due to the fact that there are no adequate railroad facilities. From the works of the Edison Company to those of the Reading Company is a distance of about fifty miles, and with the exception of the eastern end the bed as developed does not appear to be over three or four miles in width. In appearance the argillaceous limestone resembles slate, and in chemical composition it varies within the following limits:

Silica (SiO_2)	10.00 to 19.00
Alumina and Iron Oxide ($Al_2O_3 + Fe_2O_3$)	4.50 " 8.00
Lime (CaO)	38.00 " 49.00
Magnesia (MgO)	1.00 " 2.00

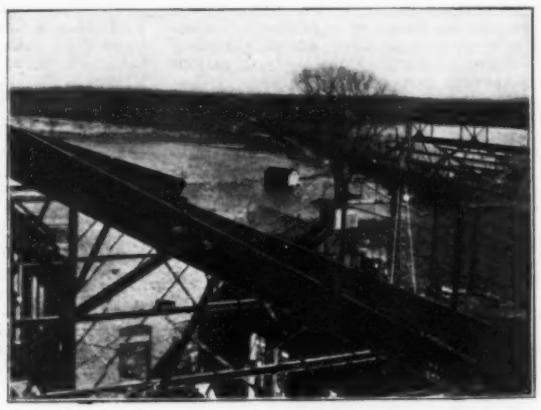
The next in order of output is limestone and clay, large works manufacturing Portland cement from these materials being located in New York, Ohio, Illinois, Virginia, Indiana, Missouri, and other States, all erected in the last four or five years, forcing marl cement from second place in 1902.

The last in the present order of output, but probably second in amount of capital invested and men employed, is marl. Perhaps a fourth should be added—furnace slag—from which considerable cement is being manufactured. Slag cement is manufactured in two ways: One method is simply a mechanical mixture of slag with hydrated lime, and the cement so manufactured is more correctly a puzzolana. By the other method a true Portland cement is produced, the slag being treated as a low-grade limestone, to which sufficient lime is added to secure a correct analysis, the raw materials being ground, mixed, and burned the same as for Portland cement.

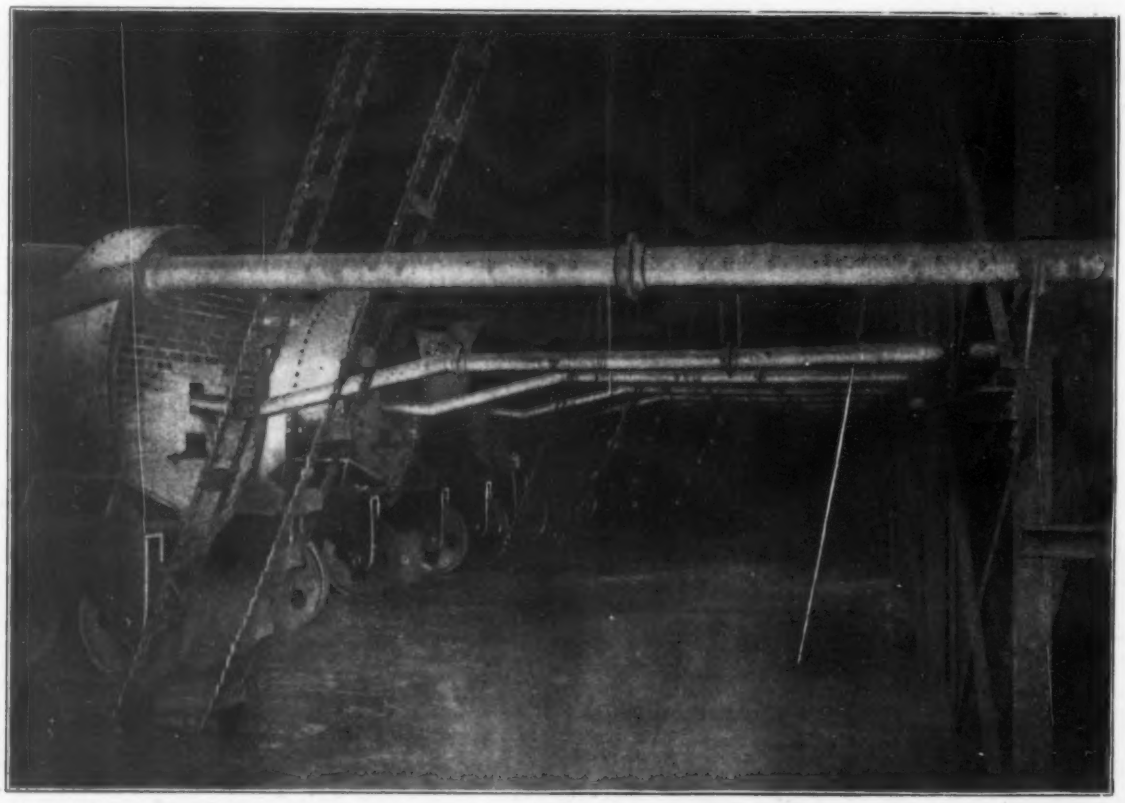
The mechanical equipment of a cement plant varies with the raw materials used, each requiring a different treatment; but the general principle is the same, the object being to secure a fine grinding and thorough mixing of the raw materials previous to calcination.

In the dry process which is used for argillaceous limestone, limestone and clay, and slag, you have as a rule hard materials which are fairly constant in their chemical composition and carry comparatively little moisture, while in the wet process which is used principally for marl the materials dealt with are soft in character, often semi-liquid, carrying, as they come from the deposit, from 40 to 50 per cent of water, and, with some methods of dredging, more. After calcination there is no great difference in the nature of the clinker, and the finishing departments of the different types of mills would be interchangeable.

OPENING UP MARL BEDS.



STEEL ROOF OVERLOOKING MARL LAKE.



BATTERY OF ROTARY KILNS—WITH FUEL PIPING AND ELEVATORS FOR HANDLING HOT CLINKER.

* Paper read before the Engineers' Club of Philadelphia and published in its Proceedings for April, 1903.

Marl is of organic origin, the deposits being found in low lands, marshes, and the bottoms of lakes. In texture it is smooth and soft, varying in consistency from that of putty to that of river mud. While the greater majority of the shells are entirely decomposed, about 90 per cent of the marl under ordinary conditions being found fine enough to wash through about a No. 100 sieve, some of the shells still retain their form. The majority of these resemble the ordinary snail shell in appearance, and vary in size from 1 and 2 inches to those that are almost microscopic. In addition to these are found the shells of the fresh-water mussel, apparently of more recent date, which are sometimes as large as your hand. I submitted some of the shells taken from a deposit in Michigan to the Academy of Natural Sciences in this city, and Mr. H. A. Pilsbry wrote me in regard to them as follows:

"The shell-fish mentioned in your letter of November 20, as found in a marl deposit in Michigan—viz., *Planorbis campanulatus, Planorbis parvus, Limnæa stagnalis, Limnæa Humilis, Physa ancillaria, Amnicola lustrica*—are all still existing as living species. The marl in question is doubtless a comparatively recent deposit occupying the bed of a post-glacial lake or pond. Similar deposits occur in northern New Jersey, where the beds of post-glacial ponds have become filled with calcareous material, largely molluscan shells.

"The cooler climate and great number of ponds and lakes which followed the glacial period favored the multiplication of fresh-water mollusks, which at that time were evidently more abundant than at present, now that the vast majority of these ponds have become extinct by cutting down of streams to their beds and diminished rainfall, etc. However, the same shell-fish may still be found in many Michigan lakes to-day. As a general rule, it requires some search to find them, except in early spring and in the fall, when they are abundant enough in suitable places."

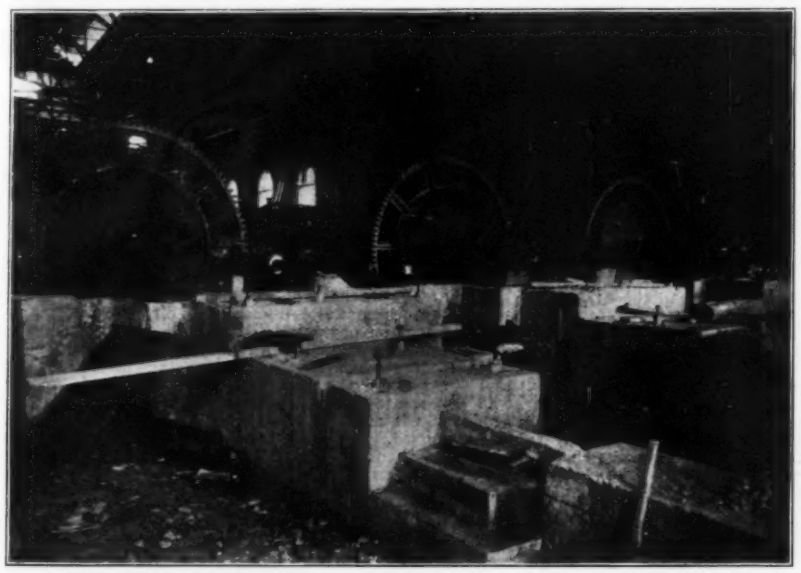
I have never observed any living specimens in the deposits examined, except a few of the ordinary fresh-water mussel.

In northern Ohio, near Sandusky, the marl deposits are of a different character, being largely of a chemical origin formed by the crystallization and deposit of lime through evaporation of the water which overflowed the low lands in periods of flood, etc. Springs in this neighborhood, which come up through the clay of crystallization and afterward decomposed, leaving in the travertine a cast of the plant. These stones are found in conjunction with granular marls, and are often of considerable size. I have only seen marl of this character in the vicinity of Sandusky, but there are deposits in New York State and elsewhere. In the organic marl deposits small quantities of travertine are found, generally under water in shallow places, the precipitation being probably due to chemical action caused by plant life.

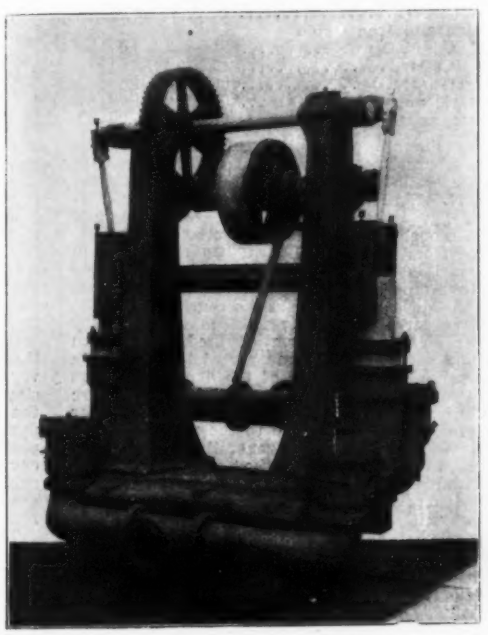
They would appear to have flourished best in shallow waters, and it will generally be found that where the water is over thirty feet in depth there is no marl under it, although fluctuations in the depths of the lakes may cause this rule to be departed from. I have observed that almost all of the lakes have an old beaver dam at the mouth, which at a later period had been reinforced by the dams of the lumbermen, which are now falling rapidly into decay. From the appearance of the deposits I would imagine that the various species of mollusks flourished along the edges in the shallow water, and gradually encroached on the lake itself, although it is possible that through the work of the beavers already mentioned the shallow lakes were gradually increased in depth and the marl deposits built up in this manner. With the exception of the presence of vegetable matter near the surface, there is no apparent difference in the analysis of marls subsoil, carry a high percentage of lime, in some instances as high as forty grains to the gallon. Large pieces of considerable hardness are frequently found, and these are known locally as prairie rock or petrified marl, and they resemble coral in their general appearance. On breaking pieces of this rock, the outline of rushes and water plants can be followed, which have apparently been incrusted during the process

The deposits of marl vary in size and depth and in many instances are covered with several feet of muck. The mollusks, from the shells of which the marl is formed, must have been very abundant at the time of the formation of these deposits, as myriads of shells would be required in their formation, and the conditions immediately following the glacial period must have been exceptionally favorable for this form of life.

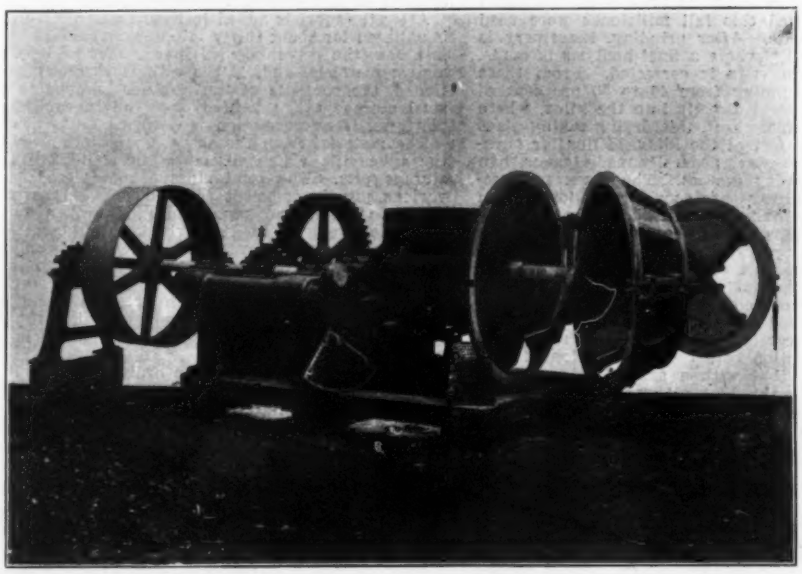
CLINKER GRINDING MACHINERY—BALL-MILLS.



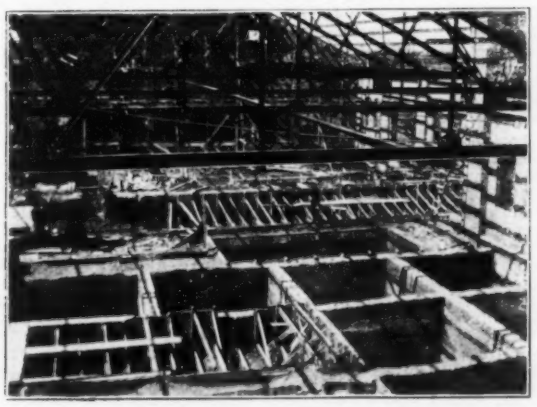
CLINKER GRINDING MACHINERY—TUBE MILLS.



CYLINDRICAL PUMP.



STONE AND GLASS SEPARATOR FOR MARL.



MIXING TANKS.

taken from the swamps and low lands and from the lakes, where it was covered from one to ten feet with water.

The deposits vary in depth from a few inches to thirty feet, but should average at least ten feet for profitable working. The surface above low water and shallow portions of the lakes are generally covered with a vegetable growth, the peat and muck running from a few inches to several feet, and this has to be stripped before the marl is excavated. If the water is over two feet in depth, the marl is generally clean.

There are few lakes or swamps in Michigan, northern Indiana, and the various portions of Canada bordering on Lake Huron, Lake Erie, and Lake Ontario, that do not contain marl to more or less extent, and I know of one deposit in Lake Huron itself. This deposit in Lake Huron is rather curious and is located a few miles north of Alpena. It has formed between a small island and the main shore. Drifting sands have practically closed the channel at one end, and the entire bay inside was filled with marl to a depth of about ten feet. The marl, however, was very soft, and an oar stuck upright in it would sink through it by its own weight. While the shells from which the marl was formed were practically pure carbonate of lime, the chemical composition of the marl varies, due to the amount of vegetable matter it contains, and also to silica, which appears to have been blown in by the wind in the form of sand. Sometimes the sand is found in layers and at other times it is mixed through the marl itself. Its presence does not seem to have been caused by the wash from streams feeding the lakes, as the marl is found to be as pure, if not purer, at the mouth of streams emptying into the lakes, as in other parts. While the vegetable matter does not directly affect the quality of the cement produced, as it is burned during calcination, it affects the value of the deposit commercially, as marl high in vegetable matter requires more fuel in its calcination and a greater bulk of marl has to be handled. If the sand is found in any large quantities—say over 3 per cent—it is very objectionable, as unless finely ground it will not combine with the lime during the passage through the kilns, and, when finely ground, it requires a higher temperature to secure combination with the lime. Marl varies in its chemical analysis considerably, but for the successful manufacture of cement it should be within the following limits:

Silica (SiO_2)	00.00	to	3.00
Alumina and Iron Oxide ($Al_2O_3 + Fe_2O_3$)	trace	"	5.00
Lime (CaO)	45.00	"	56.00
Magnesia (MgO)	00.00	"	1.50
Sulphuric anhydride (SO_3)	00.00	"	1.00
Organic matter	00.00	"	5.00

Marl deposits are plentifully scattered throughout the States bordering on the Great Lakes and in Canada, the eastern limit seeming a line drawn from Syracuse, N. Y., to about one hundred miles east of Kingston. The western line extends into Illinois and up into Wisconsin, the southern limit being two hundred miles from the Great Lakes. On the north, in Canada, marl is rarely found at a distance of over one hundred miles from the great lakes. I do not know of any deposit north of Lake Superior.

At all the larger mills the marl is excavated by mechanical means, some form of dredge or steam shovel being used. Marl is transported to the mill in various ways. If the surface of the deposit is above water and sufficiently firm, tracks are laid and cars are used; but if soft and covered with water, it is either pumped direct from the dredge to the mill or loaded into scows, in which case it is generally pumped from the landing to the mill, the method of handling varying with the conditions at each plant and the ideas of the designer.

The first mills built to manufacture Portland cement from marl and clay in the rotary kilns attempted the preliminary drying of the raw materials before grinding and mixing, but the results, so far as I can learn, were not satisfactory, due possibly to the fact that when these earlier mills were built, the cement industry was in its infancy and mechanical devices for its manufacture were not so fully developed as at the present time.

The question of drying the marl previous to the manufacture of cement is again being taken up, and I understand several mills are being designed on this principle, and one or two small ones are in operation. While there is no question in my mind as to the mechanical practicability of the drying of marl as the first step in its manufacture into Portland cement, I question whether it will be found as economical as the wet process, or will ever be commercially successful, and await with interest the results in a large mill now being built near Bay City, Michigan, where I understand it is proposed to dry the marl at the deposit, ship it a considerable distance by rail, and then manufacture it into cement. The conditions at this deposit, however, are more favorable for the success of the experiment than any other I have ever seen, as the lakes in which the marl is found are so located that with comparatively little work the outlet streams can be lowered and the water drained from the lakes. The deposits were examined by the writer's firm some years ago, and it was suggested that the outlets of the lakes be lowered, a channel cut the entire length of the lake, from which others would run at right angles to the shore, and that in this condition it might gradually dry out.

A rough experiment was made to determine the effect of drainage of the marl. A considerable quantity of marl was piled in a room, the temperature of which was about 70 deg. or 80 deg. F., but the moisture was lost very gradually. After two weeks a sample was taken from the center of the pile, and on the moisture being determined it was found to contain 32 per cent, the marl originally carrying about 50 per cent, and I question whether by any system of drainage the moisture in the marl could be reduced much below 30 per cent.

In the manufacture of cement from marl and clay it is necessary to add a considerable amount of silica and alumina, which is generally furnished by clay. For the wet process this is preferably plastic in character, and should be low in magnesia and lime and free from sand and pebbles, the combined iron and alumina in the clay being from one-half to one-third of the silica.

In the vicinity of marl deposits there is generally an abundance of clay, but it is difficult to find a deposit suitable for the manufacture of Portland cement, the majority carrying an excessive amount of magnesia, and where the magnesia is low there is apt to be an undesirable percentage of unavailable silica present in the form of sand. A number of mills started without giving the clay-supply careful consideration, and are now compelled to bring their clay from Ohio.

Shales are found in Michigan which are of good chemical composition for the manufacture of cement, but I know of no plant which is using them for their clay-supply.

Turning to the mechanical construction of a marl plant, the first problem that confronts the designer is the excavating of the marl and the delivery to the mill. This has been treated in several ways, continuous bucket dredges, dipper dredges of the clam-shell or the orange-peel type, pneumatic or hydraulic dredges all being used, but the latter process has not been found as successful as the other, owing to the large percentage of water brought up with the marl and the difficulty of separating the muck and other impurities from the marl. In some plants the marl is dredged and submitted to the preliminary preparation on the dredge, the marl being afterward forced through a pump line to the mill. Probably the most successful machine for the preliminary preparation of the marl is one resembling a mammoth sausage-grinder, which in its principle is identical with the "Universal" meat-chopper. The machine consists of a hopper of sufficient size to receive from 1 to 2 yards of marl at a time. Underneath this hopper is a powerful screw conveyor which forces the material against a perforated plate, the holes in the plate being about one-half inch in diameter. The soft marl is forced through these holes, while the grass, roots, stones, etc., are discharged from the bottom.

I have had no personal experience with the pumping of marl from the dredge to the mill, but understand that the most successful device is a double cylinder with compressed air, the marl itself acting as a piston, the device consisting of two tanks which are alternately filled and emptied. After the tank is filled, the compressed air is turned on and the contents forced into the pipe line. In the mills where I have been connected with the design, the conditions have favored the handling of the material in cars, as the greater portion of the marl deposits were above water. Tracks were laid out on the marsh and the cars run directly to the dredge, a mattress of brush being used on the softer parts. On reaching the mill the marl is dumped into a separator or pugging conveyor, thoroughly breaking it up; the marl, which is now in a semi-liquid state, being about the consistency of grout, is stored in tanks or concrete pits. The clay, which is generally brought from some distance, is then added to the marl in correct proportions. It has been customary to dry the clay, grind it, and mix it with the marl at the pug mill, but in the mill of the Detroit Portland Cement Company, which has just been started, a departure was made and the drying omitted, the two materials being reduced to a slurry separately.

On delivery at the mill the clay is first passed through a disintegrator and then into a pugging conveyor, where sufficient water is added to bring the clay to about the same consistency as the marl, and the clay is run to storage tanks, from which it is pumped with the marl into the mixing tanks, the proportion being roughly one cubic foot of clay to four cubic feet of marl. In the mixing tanks the slurry is subjected to thorough agitating, and the slurry is then ground to such fineness that 95 per cent will pass a No. 100 sieve.

The handling of the raw materials after delivery to the mill is done by pumps, three types being in use—cylindrical pumps, centrifugal pumps, and compressed-air pumps—as previously described.

For grinding the marl the wet tube-mill has been most generally used, although in some of the Canadian mills which I visited this fall millstones were used with excellent results. After grinding, the slurry is stored in large tanks, where a final analysis is made, and if necessary the mix is corrected. From these tanks the slurry running from 40 to 50 per cent of solid matter is pumped directly into the kilns, where it is dried by the waste heat, this drying taking place in the first twenty feet of the kilns. Kilns for burning by the wet process are generally made longer than those used in the dry process. The stack temperatures in the wet process are considerably lower than in the dry process, and operation shows that the calcination of the slurry consumes considerably more coal than in the dry process. I am of the opinion, however, that this increased coal consumption is not entirely due to the amount of water in the slurry, but to the more refractory character of the raw materials, and to the decreased production. In one mill some experiments were carried on to determine stack temperatures in connection with the consumption of coal, and it was found that with a stack temperature of about 400 deg. F., the best all-around results were obtained. In the dry process the stack temperatures run from 800 deg. to 1,200 deg. F., and, if the kiln is being forced, even higher.

The use of powdered coal in the burning of cement has now become almost universal, and with the exception of one or two small mills in California and Texas, oil has been entirely superseded. One mill is operated on natural gas, but I have been unable to secure any data as to capacities and outputs.

In ordinary practice the burning of cement by the wet process is more expensive for two reasons: First, there is an increased consumption of at least 50 pounds of coal per barrel of cement produced, and a decrease in production per kiln of about 50 per cent. While some mills claim to be producing by the wet process 125 to 135 barrels per kiln per day, I do not think the average is much more than 100 barrels per kiln; while by the dry process a production of over 200 barrels per day per kiln is not unusual, and I should think an average of the production of all the dry mills would show that 175 barrels has been attained, with a coal consumption of about 110 pounds, some mills where the material is easily fused dropping as low as 90 pounds.

I was very much surprised to see a record of one week's run in a cement mill recently that showed, with five kilns in operation, a production of 256 barrels of cement per kiln for each twenty-four hours, with a coal consumption of 89 6-10 pounds of coal to the barrel of cement produced. I think that record is greater than any I have ever heard of, and it is an absolutely correct one, as all the coal is weighed going into the kilns and all the cement coming out.

After burning the clinker, the process of manufacture differs in no way from that in use in the dry plants, the marl plants having an advantage over the dry plants from the fact that the clinker is more readily ground.

Comparing the manufacture of cement from marl and clay with the manufacture of cement from the argillaceous limestone of the Lehigh region, or from limestone and clay, the principal advantages and disadvantages are as follows:

In the manufacture from marl and clay the excavation and grinding of the raw materials are much less difficult, as the materials are all soft; but to counterbalance this you have the following disadvantages:

First, with each 100 pounds of raw material you have to handle 100 pounds of water.

Second, after starting manufacture the raw materials cannot be left at rest, but must be agitated.

Third, an increased fuel consumption of 50 per cent.

Fourth, difficulty of operating in cold weather.

Fifth, reduced production per kiln.

These offset any advantages gained by the softer character of the materials.

This general review of the conditions will serve to make the accompanying illustrations clearer and more easily understood.

The marl is excavated by a clam-shell dredge with a bucket capacity of 1½ yards, which discharges into the cars. These cars are brought to the foot of a double-track incline, up which they are drawn to the second floor of the marl building, which has an elevation of about 40 feet above water-level in the lake. The hoist has a sufficient capacity to haul up two loaded cars, the empty cars returning by gravity. The cars are dumped into a hopper over the separator previously described, and from this they discharge into an 18-inch ribbon conveyor which carries the marl to the six separate pits, each of which is equipped with a two-arm agitator revolving at a speed of fifteen revolutions per minute. Compressed air is being substituted for mechanical agitators in a number of the mills, and considerable advantage is claimed for its use.

The clay is brought in by the rail, and is unloaded directly into the hopper of the disintegrator, which is located in a building not shown on the plan. After passing through the disintegrator, the clay is discharged into an 18-inch cut flight conveyor, which, in addition to conveying the clay to the clay storage pits, thoroughly pugs it. It was originally intended that the clay should be discharged into a wash-pit which was equipped with an especially designed four-armed agitator similar to the wash mill used in Europe, the arms being equipped with drags; the outlets are so arranged that the washed clay could be discharged into three adjoining storage pits. It was, however, found on operation of the mills that the clay was so thoroughly disintegrated and pugged before delivery to the wash-pit, that further treatment was unnecessary, and the clay is now delivered into any of the separate pits without first going in the wash-pit, two of the arms in the wash-pit agitator having been removed. Each of these pits has a capacity of about 1,600 cubic feet. From the storage pits the material discharges through pipes by gravity to the suction of the two pumps located just in front of the storage pits for marl and clay. When mixing the raw materials, a sufficient quantity of clay is first pumped into one of the four mixing pits, then the marl is added; these pits are equipped with high-speed propeller agitators, the two pumps being so piped that one can be working on marl and one on clay at the same time, or both on one material.

After the marl is added to the mixing pit, the mass is agitated for about thirty minutes, and then a sample is taken, the percentage of lime determined by volumetric methods, and, if the mix is correctly proportioned, the contents of the pits are pumped to three steel storage tanks located over the tube-mills on a platform, if no correction is needed.

The material from these tanks is fed by gravity to the tube-mills which discharge into the five slurry storage pits. The total storage represented by the various pits is sufficient to produce 2,500 barrels of cement. The entire proportioning of the raw material is made previous to the grinding, although check analyses are taken from each pit after grinding in order to prevent the possibility of error in the mix.

From the storage tanks the finished slurry is pumped to the kilns, an even pressure being maintained by two stand-pipes through which the overflow returns to the pit from which the slurry is being pumped.

The rotary kilns are of the ordinary type, six feet in diameter, sixty feet long. Each kiln is equipped with a speed regulator, by which its speed of rotation may be varied from one turn in forty-five seconds to one turn in three minutes.

The clinker after passing through the kilns is discharged into the vaults located directly under the kilns, which are of sufficient size to admit of the kiln operating for four days without removing any of the clinker. It was hoped when the plant was designed that this storage would be sufficient to allow of the clinker cooling sufficiently to be delivered directly to the ball-mills. To better secure this end it was intended to force cold air into the bottom of the pits and exhaust it from the top. Experience elsewhere, however, developed the fact that the mass of clinker was so great that thorough cooling could not be obtained, the air seeking preferred channels, and an auxiliary system was put in, rotary coolers being used. The fans exhausting from the top are those used for blowing the powdered coal into the kilns, the air used for this purpose being heated by its passage through clinker. A considerable improvement in the opera-

tion of the kilns is effected, and consequent saving of fuel, the temperature of the hot blast being about 700 deg.

The coal is unloaded directly from the cars to an elevator, which discharges it into the hopper of a rotary drier, from which the material is discharged into a disintegrator which reduces it to such fineness that the majority of it will pass a No. 10 sieve. From this disintegrator the coal is elevated to the bin over the tube-mill, where it is ground to such fineness that 95 per cent will pass a No. 100 sieve. From the tube-mill the coal is elevated and discharged into the coal bins in front of the kilns.

The grinding machinery differs little from the standard practice, ball- and tube-mills being installed in this instance. Griffin mills are also frequently used. The entire plant is electrically driven, twenty-six motors being installed, the tube-mills, ball-mills, and other large machines having individual motors which belt directly to the driving pulley of the machinery. The elevators, conveyors, etc., are all arranged in groups, and driven through countershafts to which the motors are belted, General Electric current motors being used, varying in size from 15 to 100 horse power. The power plant is equipped with four 200 horse power Wickes vertical boilers, two 500 horse power Russell engines, and two 300 kilowatt General Electric generators, and it is contemplated in the near future to install an additional engine and generator, as the present generators and engines are loaded up to their limit, and there is no opportunity to shut off for repairs.

The plant was started in operation on October 1, and cement was ready for shipment October 15. The plant is at present only operating five kilns, as owing to a fire which destroyed the works of one of the sub-contractors, the delivery of three kilns is delayed, and they are not yet ready for operation.

The buildings are non-combustible in construction. The raw material and kiln rooms are built of brick with steel roof trusses and corrugated iron roof; the balance of the buildings are of steel and corrugated iron.

Although advocates of the wet process are enthusiastic regarding the value of marl as a cement-making material, and in the Michigan district no other material can secure a hearing, and the same condition prevails in the Lehigh region in regard to the argillaceous limestone or cement rock, I notice a growing tendency to favor limestone and clay. The mills manufacturing from these materials are widely scattered, so the growth of this portion of the industry has attracted so little attention that there may be many who will question the statement that 22 per cent of the cement manufactured in 1903 will be produced from this material. The use of limestone and clay is not confined to new enterprises, two of the largest manufacturers in the Lehigh region having erected mills in the West, and their estimated production for 1903 is 5,000 barrels per day.

The following approximate table shows the amount of cement manufactured from the different materials in the past five years, and also the growth of the cement industry for that period, and I would not be surprised if the next few years show even greater gains for limestone and clay.

Date.	Argillaceous limestone.		Marl.		Limestone.		Total.
	Production.	Per cent	Production.	Per cent.	Production.	Per cent.	Production.
1899	4,100,000	73	1,200,000	21	300,000	5	5,600,000
1901	8,700,000	70	2,150,000	17	1,850,000	13	12,700,000
1903 (estimated)	11,600,000	61	3,250,000	17	4,200,000	22	19,000,000

[Continued from SUPPLEMENT No. 1432, page 22951.]

ON ELECTRONS.*

By SIR OLIVER LODGE, F.R.S., Vice-President.

PART VI.

ELECTRIC THEORY OF MATTER.

Estimate of Size of Electrons.

ON the hypothesis that the flying or vibrating fragment is a material corpuscle charged with electricity, so that it has a duplex constitution and a compound kind of inertia, part material and part electrical, no further progress can be made. But on the hypothesis that the flying or vibrating particle is an electron—a charge of electricity and nothing else—a constituent of an atom but with no material nucleus—so that the whole of the atomic properties are to be considered as due to an aggregate of electrons of opposite size, of which one or two are comparatively free and detachable—on this hypothesis a determination of the mass of a corpuscle carries with it as a consequence a determination of its size also.

Because, as has already been pointed out, any required amount of self-induction can be conferred on a wire by making it fine enough, and any required amount of energy can be conferred upon an electric charge by making it concentrated enough. The energy at a given speed of motion will be proportional both to the quantity and the potential, and the latter can be made as great as we please by making the size of the body possessing the charge extremely small.

It is the intense region of force close to the wire or close to the charged particle which is the effective region; and so, as stated, a knowledge of the mass or kinetic energy at a given speed suffices, on a purely electric theory of matter, to determine the size of the electron constituents of which it is composed. For whether there be any intrinsically material inertia or not, there certainly is an electrical inertia. The cause of it in the electrical case is known; it is due to the reaction of the electric and magnetic fields during acceleration periods, and is denominated self-induction.

Quite possibly there is no other kind. Quite possibly that which we observe as the inertia of ordinary matter is simply the electrostatic inertia or self-induction of an immense number of ionic charges or electric atoms or electrons.

This is by far the most interesting hypothesis, because it enables us to progress, and is definite. The admixture of properties, partly explained (viz., the electrical), partly unexplained (viz., the material), lands us nowhere, unless by some only partially imagined means we were able to estimate how much of the corpuscle appertains to each ingredient.

The mass of a corpuscle has been measured at something akin to 1-1000 of an atom of hydrogen, and its charge as 10^{-10} electrostatic unit. This amount of electricity will have that amount of inertia if it exists over a sphere of radius 10^{-12} centimeter, but not otherwise. Consequently we may assume the size of the electron to be of the order 10^{-12} centimeter in diameter; or 1-100000 of the linear dimension known as molecular magnitude, viz., 10^{-8} centimeter.

With a size like that the penetrating power of cathode

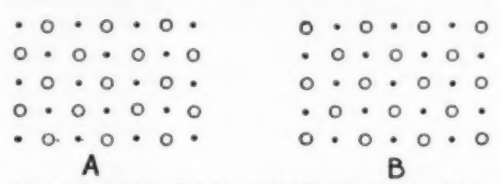


FIG. 5.—ORDINARY COHESION BETWEEN TWO NEUTRAL ATOMS A AND B: EACH ATOM CONSISTING OF INTERLEAVED ELECTRONS OF OPPOSITE SIGN, DEPICTED IN ANY CONVENIENT WAY.

rays is explained. Especially if the atoms of matter are themselves composed of such minute particles. For the interspaces will be enormous compared with the filled-up space, and a point can penetrate far into such an assemblage without striking anything.

It can be determined by considering how much space the substance of all the electrons in an atom occupies, as compared with all the space which the atom occupies itself. In other words, we have to consider what the size 10^{-12} for an electron's diameter means, as compared with the size 10^{-8} for an atom's diameter. In the solar system the diameter of the earth is 1-20000 part of the diameter of its orbit round the sun. Consequently if the earth represented an electron, an atom would occupy a sphere with the sun as center and five times the distance of the earth as radius.

In other words, if an average atom is composed of electrons, they are about as far apart in that atom in proportion to their size as the planets in the solar system are in proportion to their size.

In an atom of hydrogen there are roughly 1,000, or say more exactly 700 electrons in order to make up the proper mass.

In an atom of sodium, which is twenty-three times as heavy, there must be about 15,000 electrons.

And in an atom of mercury there must be over 100,000 electrons.

Consider then an atom of mercury containing 100,000

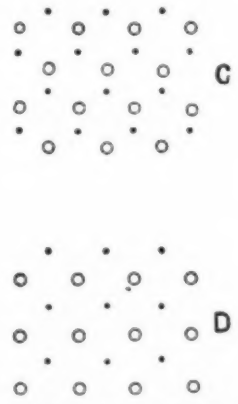


FIG. 6.—TWO POLARIZED ATOMS, POLARIZED IN DIFFERENT WAYS; ILLUSTRATING ALSO ELECTRICALLY INTENSIFIED COHESION.

of these bodies packed in a sphere 10^{-8} centimeter in diameter. One would think at first they must be crowded; but there is plenty of room. Each electron is only 10^{-13} centimeter across, and there are only about fifty of them in a row along any diameter of the atom; hence the empty space inside the atom is enormously greater than the filled spaces. At least a thousand times greater in linear dimension, or a thousand million times greater in bulk.

The whole volume of the atom is 10^{-24} c.c., the aggregate volume of all the electrons composing the atom is $10^5 \times 10^{-39} = 10^{-34}$ c.c.; consequently the space left empty is 10^{10} or ten thousand million times the filled space.

Even inside an atom of mercury, therefore, the amount of crowding is fairly analogous to that of the planets in the solar system. For though the outer planets are spaced further apart than the inner ones, they are also bigger, to practically a compensating extent.

From what is sometimes called Loschmidt's theorem in the kinetic theory of gases, the mean free path of an *electron* inside an atom of mercury will be 10^{-4} centimeter; that is, it may get through on the average the substance of some 10,000 mercury atoms in a row without collision.

In any other less dense substance it will go further. The actual *distance* thus traveled by corpuscles plunging into a dense metal is very small, only the thousandth part of a millimeter on the average, and it need by no means necessarily be a straight line; so a target of platinum succeeds in stopping them fairly near its surface, and enables the X-rays generated by the shock fairly to emerge. Some corpuscles will be stopped more suddenly than this, and some will travel further, but 10^{-4} centimeter is about the average distance traveled in a solid as dense as platinum.

This distance, however, gives no notion of the value of the negative acceleration during a collision, because the greater part of the thousandth of a millimeter is free flight; the stoppage occurs only as the last episode of that flight, viz., at the instant of collision. The colliding masses are 100,000 to 1, so the change of velocity at impact could be estimated; but the impact will really be more of an astronomical or cometary character, and the effect is analogous to the entrapping of comets when they pass near a planet, thereby rendering them permanent members of the solar system.

The *ordinary* behavior of a foreign comet, which comes and goes, may be called a collision with, and rebound from, the sun; for although there is no real encounter of main substance, that is what it would appear like if it could be seen from the depths of space; and the two branches of the comet's hyperbolic orbit would look like straight lines of approach and recession.

Comets which happen to pass very near a planet, however, are deflected, swirled round, and often virtually caught by that planet, receding only with an insignificant differential velocity which is unable to carry them away from the attraction of the sun; into which they often drop. Or if they do not actually drop into it, they will continue to revolve round it in an elliptic orbit, becoming a member of the solar system, and liable ultimately to be degraded into a swarm of meteors.

This is the sort of process known to occur in astronomy, and circumstances not unlike that may attend the encounter or apparent collision of a furiously flying comet-like electron with part of the massive system of an atom.

The stoppage, therefore, will occur well within the limits of atomic magnitude, 10^{-8} centimeter; and so the acceleration will be of the order $\frac{u^2}{2l} = 10^{28}$ c.g.s., and the force needed thus to stop even a single electron will be the tenth of a dyne.

No wonder that violent radiation-effects are produced. The "power" required to stop an electron, flying with one-thirtieth of the speed of light, inside a molecular thickness, can be estimated as 10^7 ergs per second, which is equivalent to ten watts. (Though the time it lasts is only the 10^{-17} part of a second.)

But only a small fraction of this goes into radiation. The rest, therefore, it would appear, must take the form of heat.

Effective radiating power depends chiefly on very sudden stoppage, and on the speed being near that of light. If the velocity is a tenth that of light, and if an electron can be stopped in something like its own diameter, about 10 per cent of the energy will go in radiation, and the rest will take other forms, presumably heat.

As the velocity diminishes, more and more of the energy takes the form of heat; which agrees with the fact that at moderate vacua the target gets red-hot.

The ratio of the radiation power to the total power is as the dimensions of an electron to the distance light would travel during the period of the stoppage. So to get *all* the energy radiated it is necessary to stop a pellet moving with a tenth the speed of light in something like a tenth of its own diameter.

JUSTIFICATION FOR ELECTRIC VIEW OF MATTER.

But now what justification is there for the extraordinarily far-reaching hypothesis that the electrons constitute matter, that atoms of matter are composed of electric charges, that the fundamental inertia-property of matter is identical with self-induction?

There is the reasonable philosophical objection to postulating two methods of explaining one thing. If inertia can be explained electrically, from the phenomena of charges in motion, it seems needless to require another distinct cause for it also. But this is not all that can be said; it is quite possible that direct experimental proof will be forthcoming before long. A method suggested by Prof. J. J. Thomson had reference to the proportion of radiation to thermal energy developed when corpuscles encounter a target which suddenly stops them. In so far as they consist of non-electric matter they would produce only heat by their dead collision, without any direct generation of ethereal waves. In so far as they consist of electric charges they would disperse a certain amount of radiation energy; and so the proportion of radiation to heat might afford a criterion. Hitherto, however, no adequate measurements have been made in this direction.

But there is another more likely avenue to a conclusive result. We know that when an electric charge moves with a speed approaching that of light, its inertia is theoretically no longer constant, but rapidly increases and becomes infinite when the light-velocity itself is reached, at least on the orthodox and accepted theory; and rather complicated and not quite accordant expressions for this high-speed inertia have been calculated by several mathematical physicists.

It is possible that in certain cases of the production of cathode rays a speed not far short of that of light may be reached, and the increased inertia observed. Such an experimental determination has been seriously and quite recently undertaken by Prof. Kaufmann, who employed the method indicated above of comparing simultaneously the electric and the magnetic deflection of the same set of rays submitted alternately or simultaneously to an electric and a magnetic field. Thus the velocity and the e/m ratio are both known, and Kaufmann concluded that when the speeds ap-

* Excerpt from a paper read before the Institution of Electrical Engineers and published in the Journal of Proceedings of the Institution.

proached perceptibly near the velocity of light the electrochemical equivalent m/e increased by just the amount required in accordance with pure electric theory—the theory which attributes the whole of inertia to electric influence. There appeared to be no quantitative room for any extra inertia, such as that of an inert particle of non-electric matter traveling with each projectile, retaining its inertia constant at all speeds, and so contributing nothing to the rise of inertia perceived when the speed approaches within hail of that of light.

It is too soon to be sure whether these results are trustworthy or not. The attempt is brilliant, and it can hardly be doubted that before long evidence will be forthcoming, on this and on other lines, which will enable us to accept or reject the hypothesis of the electric nature and unification of matter.

Meanwhile the hypothesis is in itself so probable that it is justifiable to attempt to look ahead and observe some of the consequences of the view that all atoms of matter are built up of the same fundamental units, and are composed of aggregates of a definite number of variously grouped negative and positive electrons, arranged in kinetic patterns and keeping apart by reason of the vigor of their own orbital motions.

At first it is not easy to do more than imagine the electrons to be statically grouped into regular patterns; arranged it may be in triangular or square or hexagonal order; with other allied three-dimensional possibilities familiar to students of crystallography.

ON CHEMICAL AND MOLECULAR FORCES.

The force of chemical affinity has long been known to be electrical. Ordinary electrical attraction between charged bodies may be called molar chemical action; only there is no combination in ordinary cases, because the opposing charges spark into one another, and so the attraction ceases when a certain proximity is reached. The idea that chemical forces are really electrical is as old as Sir Humphry Davy.

Real chemical attraction occurs between two atoms, each of which contains an odd number of electrons; one extra, or it may be more than one extra, electron of given sign. Such an atom has a center of force whereby it can attach itself to other atoms and enter into pairing or chemical combination with them. It is probable that a negative charge is an excess, and a positive charge a defect; and that when pairing occurs the excess charge of one fills up the deficiency of the other, and composes a complete and neutral molecule.

Union of this kind, however, never seems quite as strong and permanent as the union of the electrons in the atom itself; the molecule easily separates at the same place again under the influence of decomposing influences, and does not seem able to split up in other ways into new substances; except in organic chemistry, where various modes of splitting up a complex molecule can be brought about, and are practically utilized for the generation of new compounds, e. g.:

$$CH_3 . CH_3 = C_2H_5 . H.$$

It is probable that the same sort of thing is *possible* with simple bodies, but that the so-called "elements" constitute a peculiarly stable group, the ingredients of which so far have only partially been reassociated into isomeric or allotropic forms, and have not yet been detached from each other.

When chemical combination occurs between two oppositely charged atoms, there is no electric discharge between them; the two atoms retain each its own charge, and cling together for that reason. When they are separated, each is an ion and possesses its appropriate charge.

It is possible to charge an assemblage of neutral molecules with an excess or with a defect of one or more electrons, by processes of ordinary electrification, but the attachment of these supernumerary electrons is loose—and they can be shaken away by the agitation of ultra-violet light and in many other ways. Even splashing of liquids into spray shakes some loose. And in the case of massive molecules their mutual collision or agitation under the influence of ordinary temperature is sufficient to shake away some of the loose electrons, which then fly off tangentially with whatever orbital velocity they may have had; giving rise to phenomena recently discovered under the name of *radio-activity*.

MOLECULAR FORCES, COHESION.

But there is another kind of adhesion or cohesion of molecules, not chemical, but what is called molecular. This occurs between atoms not possessing ionic or extra charges, but each quite neutral, consisting of paired-off groups of electrons. At any moderate distance the force of attraction between paired electrons will be next to nothing, but at very minute distances it may be very great, ranging up to something almost indistinguishable from chemical combination, except that the cling will be a weak cling at a multitude of points instead of an intense cling at only one.

Consider the outer surface of an atom consisting of a regular group of interleaved electrons of alternately opposite sign. Its equipotential surfaces will be dimpled or corrugated or pimply sheets, which at a little distance away will be almost plain, the dimples increasing rapidly in depth and becoming like the cover of a mattress when something less than molecular distance, something approaching the internal electron distances apart, is reached.

Two such atoms will therefore tend to settle down with their equipotential surfaces adjusted into uniformity, the pimples of the one fitting into the hollows of the other; and this is the state of things suggested by the facts of cohesion (Fig. 5).

To investigate the actual law of force would be difficult, and too many assumptions would have to be made for the geometrical arrangement of the electrons in the adjacent atoms; it could only be approximate, because we should probably, at least in the first instance, have to assume a static distribution.

It is quite plain, however, that the result would be a force rapidly increasing and becoming great at small distances, and practically nil at any perceptible distance.

Molecular forces on this view are electrical, just as much electrical as are chemical forces; but they occur between chemically saturated molecules, and are due to the interaction or distant influence of paired electrons on each other across molecular distances.

Ions cannot thus combine; because if they were oppositely charged their combination would be chemical, and if they were similarly charged they would strongly repel each other.

But if ions arrive at a metallic electrode, or are provided with other means of passing on their free charges, they cease to be ions and then they can and do combine molecularly with each other.

It is of course possible for an ion to have more than one free electron, forming a dyad or a triad radical; and the way in which a neutral group can receive and by rapid readjustment pass on an extra foreign electron, reminding one of the readjustment of the films in a lather when one compartment bursts, is doubtless instructive.

The effect of electric polarization on such a neutral group of electrons is noteworthy. The effect of a charged body in the neighborhood is at once to disturb the equilibrium and to disturb the grouping throughout the atom more or less; it will cause the negative electrons to protrude slightly on one side and the positive on the other (see Fig. 6).

If two molecules were beyond each other's molecular range, and if the neighboring surfaces could by any means, by the supply of electricity from without, be oppositely electrified, the forces of cohesion would be intensified momentarily by something akin to chemical forces, and cohesion would set in over ultra-molecular distances. This appears to be what goes on in a "coherer." The opposite charges cannot be *maintained* electrostatically between two neighboring metallic surfaces, but they can be imparted with a sudden jerk or disruptive discharge or received electric impulse; and these are the things which are effective in promoting cohesion.

In the diagram herewith, Fig. 5 represents a couple of atoms with interleaved electrons of opposite sign in square order, the atoms being within range of one another and so cohering by molecular or non-chemical forces. They have adjusted themselves into a cohering position; but a shear through half the distance apart of the electrons would disintegrate them. An angle represented by half the electron-distance divided by the molecular-distance is therefore a measure of the maximum distortion of a substance.

Fig. 6 shows a couple of atoms both electrically polarized, as by a positively charged rod held above both. The constituents of *C* are polarized into hexagonal order—an effect such as might also be caused by lateral pressure in some cases; the constituents of *D* are in diagonal square order; which has the effect of violent electric polarization. The atoms *C* and *D* are therefore clinging by forces much stronger than ordinary cohesion at that distance would have been. They represent adjacent atoms of a momentarily polarized coherer.

It is not to be supposed that the electrons need really ever to be disturbed more than an almost imperceptible amount in order to produce this chemical cohesion effect.

(To be continued.)

CONTEMPORARY ELECTRICAL SCIENCE.*

RADIATION SCALE OF TEMPERATURE.—For determining the temperature of a hot body by means of the radiant heat emitted by it, three different methods are available. The first is indicated by the Stefan-Boltzmann law

$$\int_0^\infty E_\lambda d\lambda = \sigma T^4,$$

connecting the "black" radiation between the wavelengths λ and $\lambda + d\lambda$ with the absolute temperature T by means of a constant σ. The second method is based upon Wien's law

$$\lambda_m T = A,$$

and the third upon Wein's other formula

$$E_m T^{-5} = B,$$

where A and B are constants, and m refers to the maximum energy radiated at a particular wave-length. O. Lummer and E. Pringsheim point out that these laws are not merely empirical rules, but laws of Nature whose validity is as well established as the thermodynamic equations upon which gas thermometry is based. They prove by measurements with a hollow carbon cylinder heated to 2,300 deg. abs. that all three methods give identical results, and that the region of accurate measurement of temperatures is, therefore, extended by 1,000 deg., and reaches temperatures hitherto only reached by extrapolation of formulæ governing thermo-electric forces.—Lummer and Pringsheim, Berichte der Deutschen Phys. Ges., No. 1, 1903.

SPONTANEOUS IONIZATION IN AIR.—J. Patterson has endeavored to determine the cause of the so-called spontaneous ionization in air. To measure the spontaneous ionization at different temperatures, the air was contained in an insulated iron cylinder containing about 13 liters, and the rate of leak was measured between the walls of the vessel and an insulated electrode. This electrode was connected to one pair of quadrants of a very delicate electrometer and the rate of leak observed. The experiments showed that from the temperature of the room (20 deg. C.) to about 500 deg. C. the current through the gas was constant, the air in the cylinder being at atmospheric pressure throughout the investigation. To measure the ionization at different pressures the same cylinder and electrode were used. The joints were made air-tight with sealing wax and the air filtered through glass wool. The results showed that down to a pressure of about one-third atmosphere the current through the gas was independent of the pressure, and that for pressures below 90 mm. of mercury the ionization was proportional to the pressure. Using the value 6×10^{-20} for *e*, the charge on an ion, the number of ions produced per cubic centimeter per second was about 30. The results of the experiments indicate that the "spontaneous ionization" is really due to easily absorbed radiation from the walls of the vessel.—J. Patterson, Proc. Cambridge Phil. Soc., XII., 1, 1902.

CONSTANCY OF MANGANIN RESISTANCES.—S. Lindeck publishes some figures obtained at the Reichsanstalt in the course of some tests of manganin resistances made after they had been several years in commercial use. Out of 31 resistances, consisting of sheet manganin, 15 showed variations amounting to less than 0.01 per cent. Six showed 0.02 per cent of a secular alteration, five 0.5 per cent, three 0.1 per cent, and two more than 0.1 per cent. This shows that 26 out of the 31 resistances supplied to electrical works remained constant within the indications of the best direct-reading instruments. Among the 10 resistances showing alterations exceeding 0.02 per cent, seven were large resistances which had been used with strong currents. The two resistances whose variation exceeded the limit of accuracy marked on them (0.1 per cent) had been used almost daily, for four years and 2½ years respectively. The former showed a decrease of 0.12 per cent, and the latter an increase of 0.23 per cent. The latter was covered with a brown mud, produced by a chemical attack of the petroleum used upon the manganin. The other instrument had only turned brown a little. The results show on the whole the admirable fitness of these resistances for industrial use.—S. Lindeck, Zeitschr. für Instrumk., January, 1903.

POTASSIUM AMALGAM CATHODES.—The photo-electric behavior of sodium or potassium amalgam, and of the sodium potassium alloy has been investigated by Elster and Geitel. T. Lyman has studied the action of the same amalgams when used as cathodes in an exhausted discharge tube. The tube had the form of an inverted U. One of the arms contained pure mercury and the other an amalgam of potassium. Each of these could be made a cathode in turn, and thus the difference between mercury and the amalgam could be studied. Though at first the potassium amalgam was protected from illumination, this precaution proved unnecessary, for a series of experiments showed that exposure of the cathode to diffused light from an external source produced no effect upon the result. It was found that, down to a pressure of about 1 mm. of mercury, no difference could be observed between the mercury and the amalgam. But at pressures of the order of 0.06 mm., the discharge potential was three times as high with the pure mercury as with the amalgam. An alloy of sodium and potassium facilitated the discharge in a similar manner, but not so much. It is evident that negative electrons are more easily discharged when a light metal is present.—T. Lyman, Proc. Cambridge Phil. Soc., XII., 1, 1902.

MAGNETIC AND ELECTRIC DEFLECTION OF CATHODE RAYS.—It was formerly supposed that cathode rays suffer no change by reflection or transmission except in direction. But Gehrcke and Leithäuser have shown that a reflected or transmitted cathode beam is heterogeneous, and will be drawn out into a sheaf by an electric or magnetic field, although the same field is quite powerless to split the beam before reflection or transmission. On the electron theory, we might suppose that either the ratio e/m of the cathode rays is altered or that their velocity is altered. H. Starke has made some experiments to test which of these alternatives is true, and finds that the ratio of the charge to the (apparent) mass of the electrons remains unaltered, but that both reflection and transmission have the effect of considerably reducing the velocity of some of the cathode rays. He used Kaufmann's method, which employs a simultaneous electric and magnetic deflection of the rays, and provides a curve from which e/m and v can be separately calculated. The latter quantity fell to between 5.64 and 3.66×10^9 on reflection from a copper surface, and to a minimum of 3.8×10^9 on transmission through an aluminium sheet 0.002 mm. thick.—H. Starke, Berichte der Deutschen Phys. Ges., No. 1, 1903.

A BRAUN TUBE FOR ELECTROSTATIC DEFLECTION.—However advantageous a Braun tube may be for studying current curves by means of electromagnetic deflection of a cathode beam, its use is very limited when the investigation of potential curves is called for. Electrostatic deflection by external condenser plates, on the other hand, is only available when the currents alternate rapidly, since a continuous current only produces a deflection at make and break, owing to the conductivity of the ionized gas in the tube. Internal condenser plates, on the other hand, give rise to a luminous discharge at low pressures, while at high pressures no cathode beam can be produced except by means of an induction coil, and that is too intermittent for good curve tracing. A. Wehnelt has, therefore, constructed another tube with internal condenser plates in which he uses one of Wiedemann's observations—viz., that the discharge potential in a vacuum tube is enormously increased by introducing the anode into the dark cathode space. This enables the observer to use internal electrodes giving a permanent electrostatic deflection. The tube described closely resembles the ordinary Braun tube in appearance. The curve of potential for an alternating arc shows a slight elevation at the beginning of the discharge, which disappears as the discharge proceeds.—A. Wehnelt, Berichte der Deutschen Phys. Ges., No. 1, 1903.

LIGHT AND CATHODE RAYS.—Some new effects of cathode rays and light rays are described by L. Zehnder. Many salts are known to be colored under the influence of cathode rays, and to lose their color subsequently when exposed to light. The author has found that if an object is traced on a dry plate by means of cathode rays and the plate is subsequently exposed to light, it may happen that after development the portion illuminated by the cathode rays appears brighter than the rest, thus recalling the effects of solarization. "Celloidine" paper, once exposed to cathode rays, becomes less sensitive to the effects of light. If the paper is then exposed to diffuse white light, that portion becomes darker which was not pre-

* Compiled by E. E. Fournier d'Albe in the Electrician.

viously exposed to the cathode rays. It is thus possible to obtain a negative of a positive image produced by cathode rays. Solio and other papers show similar effects. A circular patch exposed first to cathode rays and then to light first becomes paler at the margin, where the cathode rays were presumably less active, and gradually the brightening extends to the center. A fixing bath bleaches the cathode-exposed portions much quicker than the light-exposed ones. Magnetically deflected cathode rays have the same effect as ordinary ones.—L. Zehnder, Berichte der Deutschen Phys. Ges., No. 1, 1903.

MOLECULAR INDUCTION.—Under this name T. Gross describes some curious phenomena of electrolysis. A square glass trough is filled with a pure concentrated solution of copper sulphate, and two copper wires, reaching nearly to the bottom, enter the vessel, and are connected outside it through a high-resistance galvanometer. A plate of zinc is suspended in the trough across the line of current and closer to one of the wires. Copper is then deposited upon the zinc, and a pretty current is observed going from the zinc plate to the more distant electrode. On pushing the zinc plate toward the latter electrode, the current is reversed. The author disposes one by one of the suppositions that we have here to do with thermal, concentration or local currents. A strong E. M. F. may be obtained by immersing three zinc plates insulated on one side into the trough, and connecting the two outside ones with the galvanometer. The author maintains that we have to do with a force not connected with chemical affinity, and, indeed, often opposed to it. He calls it molecular induction. He presupposes some effect of molecular vibrations.—T. Gross, Berichte der Deutschen Phys. Ges., No. 1, 1903.

MAGNETIC FRICTION IN GASES.—On several previous occasions H. Pellat has called attention to some remarkable phenomena seen when a strong magnetic field is brought to bear upon a vacuum discharge, and more especially upon the positive column. He describes how the positive column is squeezed together into a thin pencil, and calls this phenomenon "magneto-friction." He now gives some further particulars of it, using a tube 1 meter long and 1.7 cm. wide. As the magnetic field increases, the anode light contracts until it becomes a thin pencil. On increasing the field still further, a slight halo begins to appear round the pencil. This halo gradually increases until it obscures the central pencil, and finally the magneto-friction disappears, leaving the gas as if no field existed. This point is reached much sooner in hydrogen than in oxygen. With a field of 7,000 units, the diffusion is complete in hydrogen under a pressure of 1.3 mm. Ogygen still presents a sharp pencil, but this may be made to diffuse by reducing the pressure to 0.13 mm. Mixtures of gases have intermediate properties.—H. Pellat, Comptes Rendus, December 29, 1902.

MAGNETOMETER FREE FROM DISTURBANCE.—F. Kohlrausch and L. Holborn have devised a suspension for a magnetometer which is not intended, like that devised by Julius, to get rid of mechanical vibration, but to obviate disturbance by electrical railways and similar causes. This is done by means of an astatic combination, in which two magnets, 6 cm. long and 7 mm. thick, are connected by means of a brass rod about 1 meter long, and suspended by a platinum-iridium torsion wire. Thus the earth's field and its disturbances are completely eliminated, and the authors show that it is quite possible to carry out magnetometric measurements with the lower needle alone up to distances of 1 meter when the vertical distance between the rods is not less than 127 cm. But this is only possible in the "first chief position" of Gauss, for in the "second chief position" the influence of the deflecting magnet upon the upper needle is very marked. In the first or "end-on" position the lines of force of the deflecting magnet pass through the upper needle in a slanting direction, and it is easy to arrange matters so that the horizontal force upon it is negligible.—Kohlrausch and Holborn, Ann. der Physik., No. 2, 1903.

MECHANISM OF ELECTROCHEMISTRY.—The distance between the positive and negative electrons in the molecule has been variously calculated at 0.01 $\mu\mu$ and 0.25 $\mu\mu$ M. Reinganum, who favors the former estimate, attempts to formuate a theory of the distribution of the electrons in the molecules entering into electrochemical reactions. He finds it necessary to assume, instead of one pair of electrons as in Helmholtz's theory, that each molecule, say of HCl, contains two pairs of electrons. Electrolytic dissociation might thus be represented by a formula

$$H_{+-}Cl_{+-} = H_{+} + Cl_{+=},$$

where the metallic atom becomes positive and the radicle negative. Electrolysis would then consist in a process by which the chlorine ions give up their superfluous negative charges and become neutral molecules of the type Cl_{+-} Cl_{+-}. At the cathode an equal number of negative electrons would be given to the hydrogen atoms, so that a neutral molecule is produced of the type H_{+-} H_{+-}. The necessary passage of negative electrons would take place through the metal and the circuit would be complete. The author works out this idea for different compounds, and shows why the dissociation constant is a measure of chemical affinity. It is probable that the transfer of the supernumerary electron is accomplished even before actual electrolysis takes place.—M. Reinganum, Ann. der Physik., No. 2, 1903.

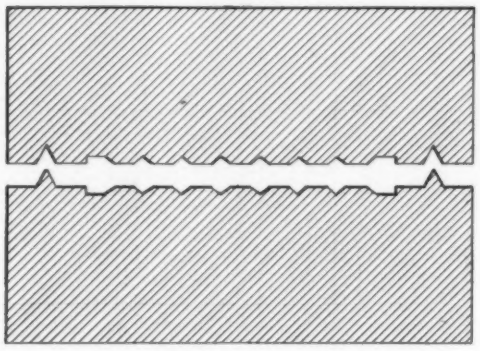
THE GENESIS OF LIGHTNING.—B. Walter proved some time ago that an electric spark originates chiefly at the positive pole, and is preceded by a number of preliminary sparks of increasing length, following each other at very short intervals and feeling their way, so to speak, toward the negative pole. Some very successful photographs of lightning flashes taken with a moving camera have since enabled him to demonstrate that the genesis of lightning is accomplished by a precisely similar process. Every flash is preceded by a number of minor flashes, branching out toward the earth. The path remains the same in all its ramifications during the succeeding flashes, though the various branches are not always equally illuminated, and further branches are added. A path once made through the air becomes, of course, conducting, and is utilized for further discharges. One of the pictures is that of a flash consisting of three main flashes, with time intervals of 0.0177 and 0.0489 seconds respectively. Another discharge consisted of five equal flashes lasting altogether a quarter of a second. One photograph shows evidence of an alternating discharge, but as a rule it may be taken for granted that the lightning passes as a series of continuous discharges, and proceeds practically from the cloud to the earth.—B. Walter, Ann. der Physik., No. 2, 1903.

A HOME-MADE STORAGE BATTERY CELL.*

By WALTER G. JONES.

THE simple storage cell, or accumulator, herewith described, is made of either cast or bored lead plates, as suits the maker, and has a capacity of about 10 ampere-hours.

The bored plates are made in a very simple manner,

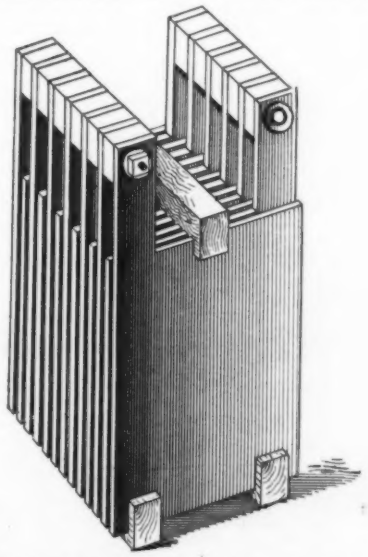


CROSS-SECTION THROUGH MOLD.

viz.: A large sheet of lead ⅛ inch thick is cut into plates 4 x 5 inches in size, care being taken to leave a long terminal or lug projecting from the plate, as shown in the cut. It is always best to have the terminals too long rather than too short, for the reason that there are certain gases continually arising from the acid in the jar, which in time may eat away the brass bolt that clamps the plates together; hence the plates make bad connection. After the required number of plates have been cut from the sheet, they are ready to be bored. In order to avoid burring or bruising the plates, clamp them two at a time between two pieces of thin wood (cigar-box wood, for instance) in a vise, and proceed to bore the holes, which should be ¼ inch in diameter. If the holes are countersunk on both sides of the plates after boring, they will hold the paste tighter.

Probably one of the best simple methods of casting plates is that given by Percival Marshall, which is explained below:

On the smooth flat surface of a slab of plaster of Paris, about 6 inches by 8 inches by 2 inches, or of a sufficient size to allow an inch or more margin around the grid, carefully make the lines as shown in cut, and with a fine chisel proceed to cut away the plaster around the squares, beveling it off to a depth of 1-16 of an inch. The sectional drawing will probably give a better idea of how the plaster and grooves should be cut. A pouring hole is made at *C*, which also forms the lug of the plate; an air hole at *A*; and



ASSEMBLED PLATES OF HOME-MADE STORAGE BATTERY CELL.

a few grooves at *BBB*, or at such places as would be convenient for aligning the other half of the mold when fixing in position for casting. To complete the mold, an exact counterpart of the half already obtained must be made. This can be easily accomplished by filling up all the grooves (except those marked *BBB*) with heated paraffine wax, pressing this into position with the fingers, and scraping it off level with the surface of the mold, thereby forming a pattern of one-half of the grid. When the wax is cool and perfectly hard, the whole impression may be removed by inserting a pin at one corner. Again the grooves of the mold must be filled with paraffine wax and scraped clean and level with the surface. The first impression should then be laid on its back on the wax at present in the grooves, and the whole mold covered with a thin coat of shellac, care being taken to keep the wax pattern in position. After building a wall of wood or heavy cardboard around the mold to a convenient height, the plaster can be poured in. When the plaster becomes hard and dry, the mold may be taken apart, all wax removed, the halves wired together, and the casting of the plates proceeded with. In casting the plates, pure lead and an absolutely clean ladle must be used. Thirteen plates (six positive and seven negative) will be needed to make the cell, but it is better to cast a few plates over and above the number required, as some of them might be defective.

After the plates have been made they are ready to be pasted. The positive plates are placed on a smooth slab and pasted with a stiff mixture of red lead and sulphuric acid (two parts water to one part acid). The negative plates are pasted in the same manner except that a stiff mixture of litharge, with the same proportion of acid and water, is used instead of red lead. The paste can be pressed into the recesses of the plates quicker and better by using a wooden spatula. In order that the paste may hold tightly, the plates are carefully pasted on both sides. When pasted, the plates should be stood up in a warm place to dry. After they have become dry and hard, they should be assembled in such a way as to allow one positive plate always to be inclosed between two negative plates, and the lugs should be accurately fastened together with long brass bolts, as shown in Fig. 3. In order to keep the plates well and evenly separated, square lead washers are used for the lugs, and wooden racks, well boiled in paraffine, for the plates.

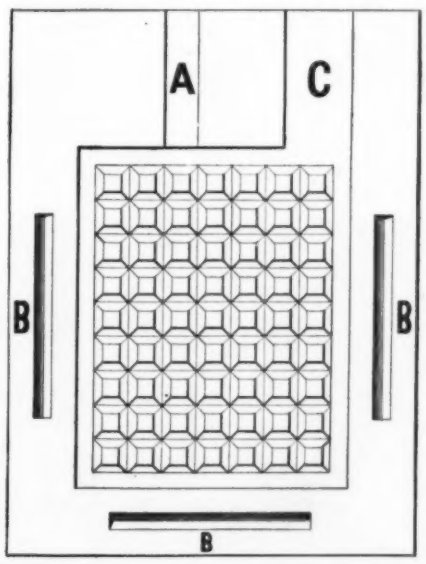
Rubber-coated wires can either be fastened under or soldered to the bolts, after which all connections on the lugs must be thoroughly paraffined. The whole mass must then be immersed in a jar containing a mixture of sulphuric acid and water (4 parts water to 1 part acid).

The process of forming the plates, which can be done if necessary with four or five bluestone batteries, must then be started. These batteries, of which the copper element is positive and the zinc element negative, have an average E. M. F. of 1 volt each, and a discharge rate of between ¼ and ¼ of an ampere. When using four of these cells and connecting them in series, an E. M. F. of 4 volts (4 cells at 1 volt each) is obtained, which is sufficient for charging the accumulator, the E. M. F. of which never exceeds 2½ volts.

If, instead of the batteries, a dynamo is used as a source of current, it should preferably be shunt-wound, for the reason that if the dynamo should fail to give current, that in the opposite direction from the storage batteries would not reverse the field, as might happen if a series wound dynamo were used. If a direct-current, electric light system is available, the easiest way to form and charge the cell is to connect it in series with a 16 or 32 candle power lamp.

Some little care must be exercised, in connecting up the cell to make sure that its positive pole is joined to the positive pole of the source of supply, and, as the E. M. F. of the primary battery or the dynamo is in constant opposition to that of the accumulator, it is necessary that this E. M. F. exceed that of the latter in order that the current shall flow.

An easy way to determine which is the positive pole, if the source of current is from an electric light circuit or a dynamo, is to hold the two wires in a glass of water, one-half an inch apart. The wire from which bubbles arise the fastest is the negative. Pole-testing paper may also be made by immersing strips of white blotting paper in a thin solution of white starch, and, after drying, again dipping them for a few seconds in a solution of ½ ounce of potassium



PLASTER OF PARIS MOLD FOR CASTING GRIDS.

iodide in 1 pint of water. A piece of this paper, moistened, and having the two wires applied to it ½ an inch apart, will turn red at the negative pole and violet at the positive.

The time taken to charge a storage cell depends entirely upon its capacity. For instance, if one wishes to charge a cell which has a capacity of 10 ampere-hours, and the charging current is 2 amperes, the time taken for charging equals 10 divided by 2, which is 5 hours. The formation of the plates in the first place takes a much longer time—anywhere from 25 to 50 hours, with this amount of current. When the plates are fully formed, the positives turn a dark chocolate color,

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

and the negatives a dark slate color. The cell will boil and gas freely, and the voltage will reach 2½ while the charging current is on. These latter conditions always occur also with a fully-charged cell. By all means never short-circuit, i. e., spark or flash the terminals of a storage battery together to see if it is charged; this is very detrimental, and will, in most cases, ruin any accumulator. A very handy way of roughly telling whether a battery is fully charged, or run down, is to connect a two-volt lamp across any single cell to be tested. If the lamp glows brilliantly, the cell is fully charged, but if it gives a dim light, the cell is discharged. When the voltage reaches 1.7 under discharge, the cell is empty and should be recharged at once. A small pocket voltmeter is the best means of testing the amount of charge in the cell. The voltage should be taken while the cell is discharging.

The E. M. F. of a lead storage cell is 2 volts, and its amperage (capacity) varies in proportion to its size. Each square foot of positive surface gives about 6 ampere-hours; therefore, if you have a battery 4 x 5 inches in size and containing thirteen plates (six positive and seven negative), the amperage would equal:

$$\frac{4 \text{ in.} \times 5 \text{ in.} \times 2 \text{ sides} \times 6 \text{ plates}}{44 \text{ sq. in.}} \times 6 \text{ amp. hrs.} = 10 \text{ amp. hrs.}$$

If it is desired to charge any number of storage cells connected in series, i. e., the positive pole of the first joined to the negative pole of the second, etc., multiply the number of cells by 2½, which will give the voltage of the charging current required. With many cells charging by gravity battery is impractical. In fact, electric light current or current from a small dynamo is by far the best source of energy.

A few cells like those described may be found very convenient by the beginner for running small fan motors and miniature electric lights.

THOMSON-HOUSTON ELECTRIC DRILL.

WE illustrate herewith a Thomson-Houston electric rotary rock drill, which in its mode of operation, presents some interesting peculiarities. The frame of the motor is immovable and is mounted through a ball and socket joint upon any sort of column, vertical or horizontal. It is capable of being placed in any direction whatever, and its position may be modified without difficulty in a few moments. The motor is completely inclosed, but it is possible to lubricate it without any difficulty, and to inspect the commutator and regulate the brushes while it is in operation. The motor is a bipolar one, is wound for 110, 220, and 550 volts, and makes 2,000 revolutions a minute. It is capable of giving from 2 to 2.5 horse power, which is sufficient for the rapid drilling of rocks of a not very hard nature. For harder ones, the company is constructing special percussion drills. The transmitting of the power of the motor is done through gearing, with, as a general thing, a ratio of reduction of 4 to 1. The gear wheel is keyed upon a tube revolving in bearings carried by two extensions of the field-magnet of the motor. Since this tube has to support the longitudinal reaction of the tool that it revolves, it is provided, in a direction opposite that of the advancement, with a bearing of special extremity consisting of a conical cup and balls that offer a very gentle rolling to the reaction.

In order to permit of the advancement of the tool without the tube participating therein, the manufacturers have made the longitudinal displacement of these two pieces independent. For this purpose, the interior of the tube is provided with a groove and with a feather stationary with respect to the tube, but capable of sliding along the tool carrier during the latter's forward motion. In order to bring about such motion, the external surface of the tool carrier is threaded, and the latter revolves in a nut. Two kinds of nuts are concurrently employed: (1) A stationary nut consisting of two pieces which the operator can cause to approach or recede in order to bring about or arrest the forward motion. The method that has been adopted for doing this is to surround the two parts of the nut with a metal band analogous to that of a band brake. This band is tightened in order to bring the two halves of the nut together, and, in case that the advancement of the tool should meet with too great a resistance, the sliding of the brake would suffice to arrest it.

(2) The stationary nut allows of too great an advance in many cases, or leads to a threading of too reduced a pitch. In fact, let us suppose that the advance be .5 of a meter per minute and the number of the revolutions of the tool be equal to 500. These data correspond to 10 threads per centimeter. In order to effect a still further reduction, the Thomson-Houston Company employs most frequently what is called a differential advance, which presents other advantages than those that we have above mentioned. Let us imagine that the nut is capable of revolving in the same direction as the screw. If it revolves as quickly as the latter, there will evidently be no advance. And this is what would happen were it controlled by a set of gears analogous to that which controls the tube to the left and which would be placed to the right on the nut. If the reduction of speed is half greater, the advancement will be reduced one-half. The first ratio of reduction remaining ¼, for example, the speed will remain 500; and if the advance of the tool remains 0.5 of a meter, it can be brought down to 5 threads per centimeter of screw length by making the ratio of reduction upon the nut equal to ⅛.—Translated from La Nature for the SCIENTIFIC AMERICAN SUPPLEMENT.

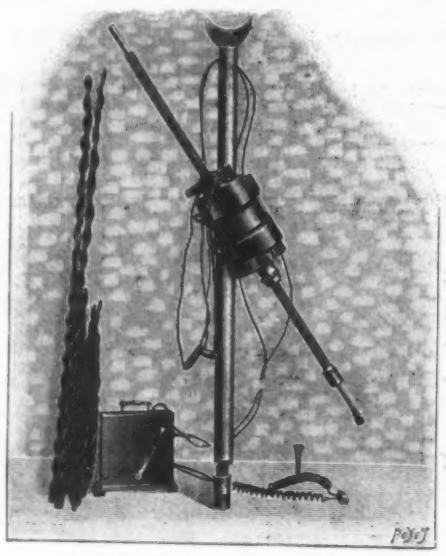


FIG. 2.—GENERAL VIEW OF THE ELECTRIC ROTARY DRILL.

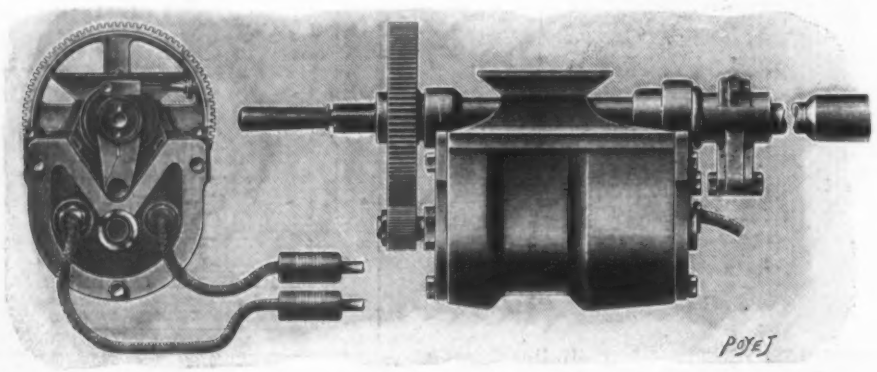


FIG. 1.—ELECTRIC ROTARY DRILL—TRANSMISSION AND MODE OF ADVANCEMENT.

ELECTROLYTIC MANUFACTURE OF CAUSTIC SODA AND HYPOCHLORITES.

WHEN common salt is electrolyzed it is separated into its constituents, sodium and chlorine, and this electrolysis may be effected by passing a proper current through fused sodium chloride, or through an aqueous solution of the salt; but in the latter case the sodium set free at the cathode immediately reacts with the water present, forming sodium hydroxide and liberating hydrogen. As shown in the discussion in Group II, the soda industry is one of the most important of the chemical industries, and as common salt is used in the Le Blanc, Solvay, and the other established processes of soda manufacture as the raw material of the art, it is not surprising that since, as stated above, common salt is readily electrolyzed, numerous processes and devices have been invented for effecting this on a commercial scale. Among them are the Vautin, Hulin, and the Borchers processes, in which fused sodium chloride is the electrolyte, and the Holland & Richardson, Hargreaves-Bird, Castner or Castner-Kellner, Solvay, Le Sueur, and the Dow, in which an aqueous solution of common salt, which in some instances is native brine, is used as the electrolyte. According to Blount,* the Castner-Kellner process is the only one which in 1900 was being worked in England on a large scale and in a profitable manner, but while this process is carried on in the United States, the Le Sueur and Dow processes are also in active operation here.

The difficulties in making the simple electrolysis of common salt a commercial success have been various. In the fused electrolyte processes they have been largely due to the corrosive action which fused salt exerts on most materials that can be used for making the vessels in which the electrolysis can be conducted, while, since the melting point of sodium chloride is 800 deg. C., and metallic sodium begins to distill below 900 deg. C., the metal comes off mostly as a vapor, which greatly increases the difficulties of collecting it. In the dissolved electrolyte processes, among other difficulties, trouble has arisen from the evolved chlorine wandering into the cathode compartment and reacting with the previously formed sodium hydroxide, or vice versa, to form hypochlorites and chlorates, while the complete separation of the caustic soda from the sodium chloride was not at first easily effected.

C. L. Parsons,* writing in 1898, says:

"Ernest A. Le Sueur enjoys the distinction of having invented the first electrolytic process for the commercial decomposition of sodium chloride, which became a regular contributor to the markets of the world. Since February, 1893, caustic soda and bleaching powder have been manufactured at Rumford Falls, Me., on a commercial scale."

It appears that Le Sueur began his experiments in the winter of 1887-1888, and after associating with him Charles N. Waite, who afforded him valuable assistance and some facilities at his chemical works in Newton, Mass., they together ran an experimental cell from October, 1890, to May, 1891, in a paper mill at Bellows Falls, Vt. In 1892 an association was formed, which in August of that year began the erection of a plant at Rumford Falls, and in February, 1893, began the manufacture of caustic soda and bleaching powder, using to generate the required current one 200-kilowatt dynamo of the Thompson-Houston pattern. The success of the venture was such that three more dynamos of the same capacity were installed in the fall of 1894, and the Electro-Chemical Company was organized.

Parsons describes the Le Sueur cell as follows:

"The cell as now used is contained in a tank 5 by 9 feet and 1½ feet deep, and made of one-quarter inch boiler steel. Excepting the asbestos, which composes the diaphragm, the wire netting of the cathode, and the materials of the positive electrode, it is built entirely of spruce, red brick, Portland cement, sand, and slate. These substances are so disposed in the cell as to be practically permanent, the wood being exposed to no action except that of the caustic solution, which has little effect upon it. The anodes are introduced from the top of the cell and may be removed singly without interrupting the process. Troublesome joints are closed with a specially prepared plastic cement. The diaphragm is tipped somewhat from the horizontal for the purpose of permitting the easy egress of the hydrogen bubbles. The foundation of the cell within the tank consists of an oblong frame of spruce, 8 feet 4 inches by 4 feet 10 inches, outside measurement, and 8 inches less on both dimensions inside. This frame is 11 inches deep, only the side pieces, however, resting upon the floor of the tank. The end pieces consist of four 4-inch timbers, whose upper surfaces are 10 inches above the floor of the tank and 1 inch below the top surface of the longer side. The frame is divided transversely by a timber, similar to each of the end timbers, which crosses the middle of the frame at the same level as the end pieces. This center beam forms a bridge over which the flat iron ribs supporting the cathode are hung. The cell is thus divided into two equal spaces merely for mechanical convenience. The ribs referred to consist of four parallel pieces of flat iron, three of them being 1½ by ¾ inch, and the fourth, twice as wide. This wider piece is fastened at both ends to the containing tank, so as to receive from the latter the electric current, which enters through the material of the tank and communicates the current to the cathode, which rests upon these iron ribs. The diaphragm rests directly upon the cathode. The depth of the trough formed by the slanting ribs is 4 inches. There is an adequate arrangement at the ends of the bridge pieces by means of which the hydrogen, finding its way to this higher level, is delivered to exit pipes communicating with the atmosphere, or with any system of piping to which it is desired to deliver it. The inch of space between the tops of the cross timbers and the side pieces is utilized to take a piece of slate 4 feet long by 4 inches wide by 1 inch thick. This presses down upon the diaphragm and the cathode netting and keeps all solid. On top of the sides and ends of the frame there are four courses of common brick laid in clear cement. There is a coating of cement applied to the inside walls of the portion of the cell forming the anode compartment, and this includes not only the brick walls, but the small portion of the wooden sides above the cathode, which would otherwise come in contact with the anode liquid. The ceiling of the cell consists simply of pieces of slate, 2 feet by 1 foot, and suitably supported by transverse strips of slate, 1 inch thick by 4 inches wide. Through the ceiling plates pass the glass tubes to which the anodes are attached.

"The anodes which are now used are made from an alloy of iridium and platinum, and are so constructed that a very large anode surface is presented at an almost incredibly small cost, when it is considered that it is not at all of the nature of a plated surface, but is an anode of solid metal. Sixty anodes on an average are used to each cell, and each anode costs 73 cents at the present market price of platinum. They are acted upon chemically but slightly, if at all. If the glass holders break there is no loss of platinum, and a new anode can immediately be put in place. The total cost for the anodes of a plant producing, per month, 200 tons of bleaching powder, is approximately $5,000, or $40 for a cell producing 55 pounds of sodium hydroxide and 50 pounds of chlorine per day; and this allows for a very low cell efficiency. The total cost for the renewal of the platinum, including labor, is less than half the cost of the bare carbon alone, as it was formerly used. Besides, it must be remembered that carbon anodes are certain to give more or less carbon dioxide if hypochlorite be present, while with these iridio-platinum anodes no carbon dioxide can possibly be produced.

"At Rumford Falls, the Electro-Chemical Company obtains power at a very low cost, so that it pays to obtain a maximum of work from each cell by using a higher current density in proportion to the anode surface than might be tenable under other conditions. As the cells are now constructed, a current of 1,000 amperes is passed through each cell under a pressure of six and one-half volts. I am aware that this

* Practical Electro-Chemistry, page 309.

* J. Am. Chem. Soc., vol. 20, page 868. 1898.

voltage is high, and from a statement in Lunge* he would probably, at first thought, condemn the process on this ground alone. But it will readily be understood how this increased voltage can be economically employed when it is considered that at $8 per electrical horse power per year, which is the cost of power to the company at Rumford Falls, the extra cost per pound of product, on an average efficiency of 80 per cent, is but $0.00015 for each extra volt used. This high voltage is by no means an essential of the process, and each cell can be run on a lower amperage, when of course less pressure would be required. It is simply a fact that at Rumford Falls it is economical to run the cells on this voltage, forcing through them all the current they can take without undue heating. Under these conditions, the renewal of the cell is usually made necessary only on account of the deterioration of the diaphragm. The diaphragms have an average life of seven weeks, and have been used twenty-four consecutive weeks without renewal. The cathodes are but little acted upon, and the steel tanks are practically indestructible.

"The cells are arranged so that twenty-two are in series, and three series are run in parallel on two dynamos. The hydrogen is used only for working platinum, the larger part being allowed to escape into the atmosphere. The chlorine is conducted by earthenware pipes to lead chambers and absorbed by lime in the usual manner, although at present a part is used for manufacture of potassium chlorate. The caustic solution is concentrated by evaporation *in vacuo*, and is separated from the major part of the undecomposed salt by centrifugals. Any chlorate is now readily removed, and the solution is then boiled down in cast-iron kettles to a first-quality caustic soda, analyzing about 74 per cent sodium oxide. The recovered salt is converted into brine and is used in the cathode compartment of the cells, nothing but fresh brine and some hydrochloric acid ever being added to the anode side. Whole bays of twenty-two cells have shown daily averages of over 90 per cent chlorine efficiency, and weekly averages of 87 per cent. If the anode compartment could be kept constantly acid, as can be done with single cells, a chlorine efficiency approaching very closely to the theoretical may be reached. The efficiency, reckoned upon the sodium hydroxide produced, is not quite so high.

"One great field for electrolytic processes is the production of bleaching liquors and caustic solutions for bleacheries, paper mills, and the like. Large economies might be introduced by companies of this kind by making their own solutions electrolytically instead of by the usual method of first transporting the chlorine in the form of bleaching powder and the alkali in the solid state. This is almost self-evident when one considers that the final evaporation of the caustic soda, which is quite costly, is done solely for purposes of transportation; that the absorption of chlorine by milk of lime is a very simple operation, and the bleach liquors so produced are much more efficient per unit of chlorine than bleaching powder; and that the raw material (salt) is easily and cheaply obtained and transported without deterioration, while a small plant can be run almost as economically as a large one. In fact, the Electro-Chemical Company has sold a great deal of chlorine in the form of bleach liquors to pulp mills at reasonable distances from the works, that preferred to take this liquid carrier of chlorine on account of its ready-settled solution, ease of manipulation, and its greater efficiency, although the cost of transportation might be somewhat greater. In works which do not require caustic soda, the process would also be highly economical, for under such conditions the cathode liquor can be directly used to absorb the chlorine, in excellent condition for bleaching purposes, thus doing away entirely with the cost and use of lime. I do not hesitate to predict that we shall yet see many Le Sueur plants established in connection with mills now using bleaching powder. In fact, one of our largest American sulphite pulp mills has already made arrangements for a trial of the Le Sueur plant, with a view of bleaching to a very large extent."

Parsons points out that the chief difficulty of the process from the outset has been to keep the sodium hydroxide in its proper compartment, for with the best of diaphragms a limited amount of diffusion into the anode compartment goes on, and sodium hypochlorite is formed, which is oxidized to sodium chlorate either before diffusion into the outer space or during evaporation of the cathode solution, and is eventually recovered as a by-product in the form of potassium chlorate. In addition, the diffusing sodium hydroxide is partly electrolyzed, and, if carbon anodes are used, the oxygen liberated will attack them, forming carbon dioxide. The sodium hypochlorite may also be electrolyzed, giving rise to nascent oxygen and increasing the amount of carbon dioxide produced, and this formation of carbon dioxide is a very serious matter, for unless removed from the chlorine gas, it renders the manufacture of a standard grade of bleaching powder impossible. Le Sueur has overcome many of these difficulties, first, by having the liquid in the anode compartment at a higher level than that of the cathode, thus diminishing the entrance of sodium hydroxide by diffusion; second, by using platinum-iridium anodes; and third, by adding hydrochloric acid to the anode compartment so as to keep the solution slightly acid. This acid, so added, at once decomposes any hypochlorite, and is itself oxidized so that all of its chlorine is regained in the form of that gas. No chlorine is lost by this operation, for the chlorine obtained as bleaching powder is greater than the equivalent of the sodium hydroxide by the amount of chlorine in the added hydrochloric acid. This use of hydrochloric acid is a matter of some expense, for an equivalent of chlorine at Rumford Falls costs more in the form of hydrochloric acid than it is worth as bleaching powder, but in other localities, and especially near the Le Blanc soda factories, such use of hydrochloric acid may prove a positive advantage from the standpoint of economy. Parsons points out that while in 1892, when the Rumford Falls plant was built, bleaching powder sold in Boston for $45 per ton and caustic soda for $74 per ton, in 1898 the prices were $30 and $36, respectively.

According to Chandler,* all the difficulties enumerated above were completely overcome by the Castner process, in which the usual porous diaphragm is avoided, and a moving cathode of quicksilver is used in its place which absorbs the metallic sodium as fast as it is produced and removes it at once from the decomposing cell to a neighboring one, where the sodium is withdrawn electrolytically and converted into sodium hydroxide. The operation is accomplished in what is known as the "tipping cell," which is so arranged that once a minute it is rocked upon its support just enough to cause the mercury cathode in the bottom to flow back and forth under the partition to and from the neighboring cell, where the sodium hydroxide is produced free from chlorine. The metallic sodium never exceeds more than 0.2 per cent of the mercury, and consequently there is very little loss from the recombination of sodium and chlorine in the decomposing cell.

An important adjunct to the tipping cell is Castner's graphitized anode. With the ordinary carbon anodes, such as have been previously employed, it was found that the combined action of the chlorine and other substances resulting from the electrolysis of sodium chloride, together with the chemical reactions which occurred at or near the surface, disintegrated them rapidly. By converting the anodes after they have been shaped and baked into the graphitic form, they are of much greater durability, and the graphitizing process has been regularly employed on a large scale for this purpose. Other modifications and improvements in the details of construction of the tipping cells have been made which facilitate the production and have increased the efficiency of the process. The Castner process yields pure caustic soda and pure chlorine, and has been in successful operation for several years in England, on the Continent, and at Niagara Falls, N. Y. At the last-named locality the company now using it is extending its plant.

According to Blount,† the Castner-Kellner process is at work in England, at Weston Point, in Lancashire, where a plant of about 1,000 horse power is in use and where a second plant of equal size is now being put down. Another plant of 2,000 horse power (also about to be doubled), belonging to the Mathieson Alkali Company, is running at Niagara, using current supplied by the Niagara Falls Power Company. The output of this company is stated to be 10 tons of caustic soda and 24 tons of bleaching powder per day of twenty-four hours; the current efficiency, from 85 to 90 per cent; the pressure required, 3.5 volts—i. e., the energy efficiency is from 55.6 to 58.9 per cent. These statements are found to be concordant if we assume that the joint efficiency of the transformers and dynamos is 80 per cent.

This is not an unreasonable loss, inasmuch as the current has not only to be let down in voltage, but has to be transformed from an alternating to a direct current. The current comes from the power house at a pressure of 2,200 volts; it is transformed down in stationary transformers to a pressure of 120 volts. At this pressure the current (which is, of course, still alternating) passes to motor transformers, which transform it to a direct current delivered at a pressure of 200 volts, this being a convenient voltage for working a group of electrolytic cells.

The anodes used are ordinarily "squirted" carbons; they are subjected to a "special treatment," designed to render them more refractory, and are said to last a year. Connection is made with them by means of a lead cap cast on one end. The caustic soda solution obtained is fairly concentrated, e. g., about 20 per cent strength. Much is sent in liquid form in tank wagons to soap-makers in Buffalo, about 20 miles from Niagara. Some is boiled down and sold in the solid state to the Electro-Chemical Company, whose works are close to those of the Mathieson Alkali Company.

The Dow process, as set forth in United States patent No. 621,908, of March 28, 1899, has for its object the production of the chlorine and sodium hydroxide from common brine, consisting of sodium chloride, calcium chloride, and magnesium chloride in aqueous solution, and the invention is in the peculiar kind of diaphragm employed and its method of formation. To form this diaphragm a quantity of metallic iron is introduced into the brine in the neighborhood of the anode. On the electric current being passed through the solution the first actions that take place are the decomposition of the electrolytic solution near the anode and cathode, free chlorine being formed at or near the anode, and free sodium, calcium, and magnesium being formed at the cathode. These latter in turn react with the water of the electrolyte to form sodium, magnesium, and calcium hydroxides, this formation also taking place near the cathode, thus: $2Na + 2H_2O = 2NaOH + H_2$. Part of the chlorine at the anode combines with the iron and forms iron chloride ($3Cl_2 + 2Fe = 2FeCl_3$). The sodium, calcium, and magnesium hydroxides and the iron chloride diffuse toward the middle of the cell and meet between the electrodes. On such meeting the iron is precipitated as iron hydroxide, which forms part of the diaphragm.

$$3NaOH + FeCl_3 = Fe(OH)_3 + 3NaCl,$$
$$3Ca(OH)_2 + 2FeCl_3 = 2Fe(OH)_3 + 3CaCl_2,$$
$$3Mg(OH)_2 + 2FeCl_3 = 2Fe(OH)_3 + 3MgCl_2.$$

Calcium and magnesium hydroxides are precipitated by the sodium hydroxide from the calcium and magnesium chlorides,

$$2NaOH + CaCl_2 = Ca(OH)_2 + 2NaCl,$$
$$2NaOH + MgCl_2 = Mg(OH)_2 + 2NaCl.$$

The diaphragm begins to form and build up from these precipitates, consisting of iron, calcium, and magnesium hydroxides. The chlorine diffusing toward the cathode on passing into the diaphragm, is absorbed by the calcium and magnesium hydroxides, forming calcium and magnesium hypochlorites, thus preventing the contamination of the cathode solution by the chlorine. These hypochlorites, whose formulæ are not positively known, decompose very rapidly, probably into chloride and oxygen. In actual working these hypochlorites are not found present. The iron hydroxide being inert so far as the chlorine is concerned, is not disturbed, so that eventually the side of the diaphragm near the anode is almost completely depleted of calcium and magnesium hydroxide by the action of the chlorine, and only iron hydroxide is left, while the cathode side consists mainly of calcium and magnesium hydroxides. The iron hydroxide prevents to a great extent the chlorine of the anode compartment from being consumed by the parts of the diaphragm with which it will combine. As the pores of the diaphragm contain iron, calcium, and magnesium chlorides, the sodium hydroxide of the cathode side upon entering the diaphragm is absorbed by these chlorides before it can diffuse to the anode side, so that the sodium hydroxide cannot contaminate the anode solution.

Thus the products of electrolysis are effectually prevented from passing into and contaminating the opposite solutions. The precipitation and formation of the diaphragm will take place most rapidly where the diffusion is the greatest, and should any portion become detached or mutilated diffusion will be greater at the mutilated point, and the consequent greater precipitation at this point will mend the break. It is thus seen that the diaphragm will thicken evenly. While one or more sheets of porous material—such as paper, cloth, asbestos, and the like—might be placed as a nucleus upon which the two essential layers of the diaphragm would be precipitated in the practical working of the cell, such a procedure has not been found necessary or advantageous, the diaphragm being readily produced in the proper place without such foundation. The physical qualities of the mixed hydroxides when made into a diaphragm in this manner are such that they form a coherent and self-supporting mass offering very little resistance to the passage of the electric current, but at the same time they offer a high resistance to the diffusion of the products of electrolysis and the electrolyte.

In the Dow process carbon electrodes are used. In all the processes bleaching powder is produced by absorbing the chlorine in dry slaked lime kept at a temperature below 46 deg. C. The yield of bleaching powder from 100 pounds of good lime is 150 pounds.—Census Bulletin 210.

TRADE NOTES AND RECIPES.

Solder for Aluminium.—A solder for aluminium, which forms the subject of a recent United States patent, consists of aluminium 5 parts, antimony 5 parts, and zinc 90 parts. To make it harder, use a little more antimony and a little less zinc. The solder is prepared as follows: The aluminium is first melted in a pot. The zinc is then added, and when this is melted the antimony is added. The metal is then thoroughly puddled with sal-ammoniac. When the surface of the metal is quite clear and white it should be poured into sticks ready for use, the cinder being first removed.

Solvents for Celluloid.—Celluloid dissolves in acetone, sulphuric ether, alcohol, oil of turpentine, benzine, amyl acetate, etc., alone, or in various combinations of these agents. The following are some proportions for solutions of celluloid:

		Grammes.
1.	Celluloid	5
	Amyl acetate	10
	Acetone	16
	Sulphuric ether	16
2.	Celluloid	10
	Sulphuric ether	30
	Acetone	30
	Amyl acetate	30
	Camphor	3
3.	Celluloid	5
	Alcohol	50
	Camphor	5
4.	Celluloid	5
	Amyl acetate	50
5.	Celluloid	5
	Amyl acetate	25
	Acetone	25

—Neueste Erfindungen und Erfahrungen.

Production of Artificial Marble.—A new process by L. Beaumel has for its purpose the production of imitation of statuary marble, onyx and other multicolored kinds of stone. The mass used consists of alum and heavy spar (barium sulphate) with addition of water and the requisite pigments.

The following proportions have been found to be very serviceable: Alum, 1,000, heavy spar, 10 to 100, water, 100, the amount of heavy spar being governed by the degree of translucence desired.

The alum is dissolved in water with the use of heat. As soon as the solution boils mix in the heavy spar stirred with water and the pigment; boil down until the mixture has lost about 3 per cent. of its weight, at which moment the mass exhibits a density of 34 deg. B. at a temperature of 100 deg. C. Allow to cool with constant stirring until the substance is semiliquid.

The resultant mass is poured into a mould covered on the inside with several layers of collodion and the cast permitted to cool completely in the mould, whereupon it is taken out and dried entirely in an airy room. Subsequently the object may be polished, patinized or finished in some other way.—Neueste Erfindungen und Erfahrungen.

Dressing for Sewing Thread.—For colored thread: Irish moss, 3 pounds, gum arabic, 2½ pounds, Japan wax, ½ pound, stearine, 185 grammes, borax, 95 grammes; boil together for one-quarter hour.

For white thread: Irish moss, 2 pounds, tapioca, 1½ pounds, spermaceti, ¾ pound, stearine, 110 grammes, borax, 95 grammes; boil together for 20 minutes.

For black thread: Irish moss, 3 pounds, gum Senegal, 2½ pounds, ceresine, 1 pound, borax, 95 grammes, logwood extract, 95 grammes, blue vitriol, 30 grammes; boil together for 20 minutes. Soak the Irish moss in each case over night in 45 liters of water, then boil for one hour, strain and add the other ingredients to the resulting solution. It is of advantage to add the borax to the Irish moss before the boiling.—Leipziger Färber und Zeugdrucker Zeitung.

* Alkali Industry, vol. 3.

* The Mineral Industry, vol. 9, page 765. 1901.

† Practical Electro-Chemistry, pages 313-314.

TRADE SUGGESTIONS FROM UNITED STATES CONSULS.

International Food Exhibition at London.—Under date of May 4, 1903, Consul-General H. Clay Evans, of London, transmits the prospectus of the International Food, Grocery, and Allied Trades Exhibition to be held at the Crystal Palace from August 29 to September 12, 1903. The industrial and commercial exhibits will be grouped under fifteen classes, seven for food preserves of all kinds and three for beverages, including natural and artificial mineral waters and non-intoxicating beverages. Group XI. includes table decorations, kitchen utensils, silver, porcelain and glassware, and table linen; Group XII., apparatus for brewers, bottlers, restaurateurs, bakers, butchers, and allied trades; Group XIII., hygienic clothing; Group XIV., social economy; Group XV., journals, newspapers, and books. Applications for space must give full name and address of applicant, stating frontage and depth of space required, with general description of exhibit. The charge for space inside the building will be 3s. (73 cents) per square foot, with a minimum charge of £3 ($14.60). Payment to the extent of 50 per cent must accompany the application, the balance to be forwarded on or before August 25. Exhibitors will have to pay all expenses of conveying, delivering, arranging, and removing their exhibits, and also the cost of the erection of all fixtures, screens, and counters required. Goods may be sent directed to the care of the Crystal Palace Company, and communications addressed to the commissioner, 20 Victoria Street, Westminster, London.

Wireless Messages from Moving Railroad Trains.—Consul-General Richard Guenther reports from Frankfort, April 25, 1903:

The Berlin Tageblatt publishes a message sent by its correspondent from a moving railroad train between Rangsdorf and Zossen, stating that on that day experiments in this line were made by the Association for Wireless Telegraphy, Braun-Siemens system. During the journey a lively communication was held between the moving train and the stations of Marienfelde and Rangsdorf. The absolute reliability of the messages transmitted was proven.

Exposition at Sivas, Turkey.—Consul M. A. Jewett sends the following from Sivas, April 18, 1903:

The local government proposes to have an exposition of native industries and products at Sivas next autumn. It will be something like our State or county fairs, and the first one of the sort ever held in this part of the country. I think it will afford an excellent opportunity to display American manufactures, particularly agricultural machines and implements. I would suggest that manufacturers send to the consulate large illustrated poster announcements of their products, and I will endeavor to have them placed where they will attract attention. Announcements in French would be more suitable than in English. Some Turkish writing might be added here. Registered post is the best method of sending advertising material.

Bicycles in China.—Consul John Fowler, of Chefoo, under date of March 26, 1903, writes in regard to the need for a touring bicycle in China. It is strength, he says, that is wanted, not style or flimsy adornments; the tool box should be complete, and the tools made of steel or some other metal not easily broken. There is a good demand for wheels among the Chinese, and a plain, strong, durable machine will sell widely at a remunerative price. He quotes from the North China News a statement in regard to the details of construction of wheels for the Chinese trade that was printed in Advance Sheets No. 1613 (April 6, 1903).

Request for Trade Information.—The Bureau of Foreign Commerce has received from O. Obermeyer, of Stuttgart (Silberburgstrasse 1251), Wurtemburg, a request for the publication of the fact that he is desirous of obtaining the names of United States manufacturers of all kinds of tools for saddlers, tanners, carpenters, coopers, cabinetmakers, turners, and butchers, as also manufacturers of drills of wood and iron material, saws, edge tools, etc.

Moss Litter for Horse Bedding.—Under date of May 7, 1903, Consul F. W. Mahin, of Nottingham, reports as follows:

For several years the so-called "moss litter" taken from the British bog lands has been used as bedding for horses, large companies now rarely employing anything else. It is considered both economical and healthful. Compared with straw, its first cost is one-half or less, 1 ton of moss litter going twice as far, at least, as 1 ton of straw. Moss litter is claimed to be a natural disinfectant, deodorizer, etc. The overpowering odor emitted by straw bedding when a barn door is opened in the morning is entirely absent from moss litter. Drains in stables, another source of danger, may be hermetically sealed, it is averred, where moss litter is used. Its absorbent quality is put at ten times its own weight in moisture. Moss litter is coming into use in many Continental army stables and is being advocated for the British army.

INDEX TO ADVANCE SHEETS OF CONSULAR REPORTS.

No. 1660, June 1.—New Railroad in Veracruz—British Lace and Hosiery Exports—Malta Import Regulations—Hebrew School of Agriculture in Germany—Customs Duties on Small Shipments to Mexico—Railway Project in Cuba.

No. 1661, June 2.—*American Corn at Havre—Austrian Prizes for Designs for Raising Canal Boats—*International Food Exhibition at London—*Moss Litter for Horse Bedding—Medical Preparations in Hungary—Electric Tramway in Derby, Eng and—*Pier at Smyrna.

No. 1662, June 3.—Trade of Denmark in 1901 3—New Breakwater at Malta—Coffee Legislation in Sao Paulo.

No. 1663, June 4.—Bagdad Railway and German Commerce in Asia Minor—Strike of Glassworkers in Bohemia—Almond Outlook in Spain.

No. 1664, June 5.—New Microscope in Germany—Trade of Fuchau in 1902—Legislation of Foreign Documents in Cuba—Clearance of Merchant Vessels for Cuban Ports.

No. 1665, June 6.—New Treatment for Tuberculosis—*Request for Delinting Machines for Cotton Seed—*Transit Dues on Goods for the Transvaal—*Venezuelan Duty on Pine.

The Reports marked with an asterisk (*) will be published in the SCIENTIFIC AMERICAN SUPPLEMENT. Interested parties can obtain the other Reports by application to Bureau of Foreign Commerce, Department of State, Washington, D. C., and we suggest immediate application before the supply is exhausted.

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